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Abstract

In November 1983 the Military Airlift Command (MAC) commissioned an evaluation of its air transportation training program. The resulting recommendations focused on coordinating the efforts of on-the -job training (OJT), formal classroom instruction, and computer based training (CBT). In January 1985 the 1492d Air Transportation Training Center was created at Travis AFB, California, to develop formal courses and a Module Development Center (MDC) to implement Air Transportation Computer Based Training (ATCBT) at 56 sites around the world. During the 6 years of its operation, the CBT inventory grew to 151 lessons. In this paper the authors will share the lessons learned in implementing the original computer based training program. The areas to be addressed are

a. system development - The first generation ATCBT system operated on an 8088 microcomputer with limited capabilities and evolved to the currently used 80286 computer system. An 80386 microcomputer system is planned for implementation in 1991/92 to incorporate system enhancements.

b. lesson enhancements - Initial lessons were formatted in low end, visual graphics (CGA) with one way, sequenced page flipping lessons. As lessons were critiqued by the field and updated by the staff, improvements were incorporated.

c. lesson developer training - individuals assigned to the MDC are air transportation specialists with varying levels of computer literacy. Maximizing productivity of personnel assigned for only 3 years presents a veritable challenge.

d. maximizing staff productivity - Integrating the teaching staff of the formal school into the ATCBT review process speeded up lesson review.

Author's Biographies

<u>MAJOR THOMAS L. ALSTON</u> Was the commander of the Military Airlift Command's Air Transportation Training Center for three years. He has a Masters of Education Degree with 10 years teaching experience in professional military education and college transportation courses.

<u>MSGT STEVEN J. DEY</u> Is the NCOIC of the MDC and has worked a myriad of air transportation jobs. He has been involved in the ATCBT program since its infancy at the user and program management levels. MSgt Dey has an Associate of Applied Science Degree in Logistics Management.

<u>TSGT JAMES J. BRUFLODT</u> Is the Assistant NCOIC of the MDC. He served 4 years as a Master Instructor with the Air Training Command and 4 years as a unit ATCBT manager. TSgt Bruflodt has an Associate of Applied Science Degree in Logistics Management.

LESSONS LEARNED IMPLEMENTING AIR TRANSPORTATION COMPUTER BASED TRAINING IN AN OPERATIONAL ENVIRONMENT

Major Thomas L. Alston

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Introduction

"More interesting," "...held my attention," "...an excellent training media." These are but a few of the student feedback comments we frequently receive about our Air Transportation Computer Based Training (ATCBT) system. Perhaps you are involved in a computer based training program or have heard CBT is the wave of the future and would like to purchase a system to take advantage of its training capabilities and enhance your work force. In this paper, we will share the lessons learned over six years in implementing our CBT program and provide some recommendations for preventing or lessening the impact of similar problems. Although this paper has been a group effort of three authors, it's an aggregation of the experiences of each member of the ATCBT team, past and present. The lessons learned will have their greatest impact on other Air Force career fields and sister services if they are currently using or contemplating the implementation of computer based training. Civilian training programs may also derive benefits from this paper. The focus of our experiences will be on four distinct areas: system development, lesson enhancements, lesson developer training, and maximizing staff productivity. To better understand the context of our experiences, we will first provide you with a brief history of the factors which prompted our system's development.

Supervisors and managers are always looking for more interesting and challenging training methods to increase worker productivity and flexibility. In the Air Force, we must continuously train a young, inexperienced work force that is mobile, rotating through different jobs and between numerous locations. Prior to 1985, the air transportation career field relied heavily on correspondence courses, on-the-job training (OJT), and tape-slide presentations of subject matter to train its work force. Dissatisfied with the passive nature of much of its training programs, the Military Airlift Command (MAC) commissioned an evaluation of its entire air transportation training program in November 1983. The panel recommended the continuation of the OJT and correspondence upgrade programs, the incorporation of formal intermediate and advanced air transportation courses, and an interactive computer based training program to provide a well-rounded and comprehensive training program throughout the air transportation specialist's career. The 1492d Air Transportation Training Center was established at Travis Air Force Base, California, in January 1985 to implement a coordinated training program and act as a focal point for training issues. The training center developed three intermediate level courses for air cargo and air passenger specialists, an advanced Air Transportation Managers' course, and the Module Development Center (MDC). The charter of the MDC is to manage MAC's worldwide Air Transportation Computer Based Training (ATCBT) program and develop a working partnership with the Air Force Reserve and Air National Guard and their Air Reserve Component Computer Based Training (ARCCBT) program which shares the ATCBT lesson inventory. Since its implementation in 1985, the ATCBT system expanded to 56 locations worldwide, providing 151 lessons to a training population in excess of 12,000 personnel. The MDC provides system support to each licensed site, performs lesson reviews, incorporates necessary changes and upgrades to both lessons and the system operating environment, processes and analyzes student data and system usage from each site, acts as a focal point for review of new contractor-developed lessons, develops lessons and graphics on a variety of air transportation operations, and provides training workshops for field training managers. The staff assigned to the MDC has varied from six to nine personnel. Air transportation specialists comprise the staff and come to the job with a variety of computer experience, from computer illiterate, to PC enthusiasts, to some with formal college computer instruction. During its six years of

operation, the ATCBT program has undergone numerous enhancements as personnel became experienced and comments were received from field sites identifying problems and deficiencies.

<u>System Development</u>

An ideal CBT system would consist of equipment at the forefront of technology in both hardware and software, with a complete lesson package requiring no changes or upgrades. The Air Force, however, is characterized by constant changes in equipment, job procedures, and technical references resulting in a never-ending series of changes to student lessons. Since a complete package of lessons was not available, the Training Division of Headquarters Military Airlift Command (HQ MAC) made a conscious decision to contract an initial set of lessons and add lessons in increments. As the inventory grew past 100 lessons, the storage capacity of the initial computer system was exceeded.

The initial ATCBT system operated on an 8088 microcomputer equipped with a single 20 megabyte hard drive containing both the system and lesson inventory. Lesson pictures were in Color/Graphics Adaptor (CGA) resolution graphics (low-end graphics capability). This system was implemented at five locations for testing. A contractor was selected to produce the initial lessons which explained the specialty training standards (STS) or tasks of the career field (Figure 1). Due to an ever growing lesson inventory, MAC quickly decided to upgrade to an 80286 microcomputer with two 20 megabyte hard drives: one drive for the operating system, data management programs, and 40 lessons; and the second drive for the remaining lesson inventory. Each major unit workcenter received a dedicated ATCBT computer. The initial ATCBT equipment setup expense was $3,130 for a single stand alone training site and $4,198 for each central training manager's site (Figure 2). Additional software expenses of $350 were required for each stand alone system and $450 for each training manager site (Figure 3).

Part of your software purchase will include your CBT system environment and a run-time module to execute lessons. The decision to develop your own software or purchase an off-the-shelf system is an important one. If you design your own environment, the software becomes the property of your organization and can be copied and distributed to any new training sites that come on line. Contractor-developed and off-the-shelf software environments are copyrighted, and you will need to purchase identical software packages for each training site. This can be expensive and can limit your capabilities since no modifications can be made to copyrighted software. Our corresponding ATCBT software, referred to as CDSX and Control, were contractor-developed and require a $350 investment per site (Figure 3).

The CBT system was reevaluated in 1989, and the training center staff determined, through management data and student feedback, that lesson quality needed improvement to increase training effectiveness and student usage. In response to this, the decision was made to improve text readability, standardize screen faces, upgrade graphics to the Enhanced Graphics Adaptor (EGA) system (mid-level graphics capability), and incorporate student control features. The system conversion to EGA resulted in problems with file size in relation to available disk space, graphics and text screen redesign, and additional equipment costs. Of the 138 available lessons, only 66 could be stored for student use. Lessons were prioritized by trainee usage and importance, converted with minimal correction, and redistributed to the field in March 1990 for use.

To reload all 138 converted lessons and an additional 13 new lessons developed by a contractor, replacement of the two 20 megabyte hard drives was needed. A study determined a single 340 megabyte hard drive would adequately hold all developed lessons and accommodate the projected new lessons under development. In addition, the system would adequately support the more extensive ARCCBT data management requirements for our Air Reserve Component counterparts. The cost estimate to procure 164 of these 340 megabyte hard drive units was $286,000 from a sole source distributor and would not have guaranteed compatibility with our current system which was at the end of its 5-year life cycle. A further comparison was conducted for a complete hard drive

replacement based on negotiated contract prices. To upgrade to an 80386 microcomputer replacement would cost an estimated $266,000 for all 164 existing terminals--$20,000 less than reconfiguring the 5-year-old equipment. HQ MAC decided to replace all systems and upgrade to a faster, more efficient system with additional memory and Video Graphics Array (VGA) capability (high-level graphics capability) for future development.

Choosing computer hardware that is both the industry standard and state-of-the-art is essential to the success of CBT. System speed, graphics capability, and storage capacity are all important considerations and should not be sacrificed because of costs. If lessons are to be added over a period of time, be sure the system has the hard disk storage capability for the entire library of lessons and data management functions. Delaying implementation a year in order to purchase the most efficient system available could be a positive cost trade off to maximize student usage and author effectiveness.

Lesson Enhancements

Based on student feedback and our developers' experimentation, we have incorporated numerous changes to our original CBT design. Trainees used the ATCBT student comment file feature to identify lesson problems, inaccurate information, and provide feedback to the MDC staff on possible enhancements to improve lessons. Although not all lessons contain the enhancements listed below, as each is reviewed and updated, it will be modified to include these student-centered features:

a. Bookmark - Allows lesson reentry at an identified interruption point.

b. Page browsing - Allows students to page back or forward while taking a lesson.

c. Page numbering - Provides students and authors the page location within lessons.

d. Review quizzes - Periodically checks student understanding of subject matter and reinforces learning.

e. Centralized Glossary - Provides student access to terminology, abbreviations, and acronyms.

f. Problem solving screen masks - Allows simulated form data entry and computer command entry training.

g. Enhanced graphics - Allows creation of more true-to-life images, forms, and screen masks.

The bookmark feature marks the point at which a student exits from a lesson prior to actual completion. The student is able to return at a later time and resume the lesson at the previously marked point. Since the bookmark relates to individual student files, the actual lesson is unaffected. This feature has proven to be beneficial since many of the lessons are 40 minutes to an hour in length. Since students perform training during work hours at their sections' computer terminals, they can be interrupted to perform actual duties. The bookmark prompt appears on a selection menu frequently throughout each lesson allowing the trainees to quickly exit to perform a task and then return where they left off (Figure 4).

A second desirable feature on the selection menu is page up, sometimes referred to as page browsing (Figure 4). This enables students to return to a previous screen for review or clarification. When a lesson contains a series of text screens, students have the capability to go back and reread pages to ensure they understand the material presented. Students no longer have to exit from a lesson and completely restart the segment in order to review a previously displayed page of information. Page browsing not only increases understanding, but gives the student more control of the lesson and reduces the potential for failure of lesson exams.

The capability to know your location within a given lesson is beneficial for students and authors. Our page numbering feature provides a road map of where you are among the total screens within the lesson segment being taken (Figure 4). This feature helps students gauge the amount of time needed to complete the segment and is an essential element for the student comment file. Students can identify specific screen numbers which may contain erroneous information or malfunctions, enabling the authors to quickly locate and correct the deficiencies. This feature also

.ds the subject matter specialist (SMS) in the annual review of lessons.

To reinforce student understanding, each lesson segment contains a number of review quizzes. These quizzes contain multiple choice, true/false, or short-answer/ fill-in-the-blank questions and are strategically placed throughout the lesson segment. The location of review quizzes are based on the length and complexity of the lesson segment being taken. Although we have no hard, fast rules for quiz placement, frequency, or numbers of questions, we have found the best ratio is a review quiz of two or three questions for every four to six screens of information. If first-try questions are answered incorrectly, the student is informed of the error and the lesson then enters a separate review unit. This unit contains the corresponding lesson information and is presented in a slightly different format. The student is then given another opportunity to answer the question. If the response is incorrect again, the answer is given and the lesson advances to the next question. If answered correctly, the student is given a short reinforcement and the review quiz continues. Upon completion, the lesson continues to the next learning area. The review quizzes also prepare students for the segment test as they have a 40 to 60 percent sampling of the questions to be asked.

Many times, student misunderstanding is due, in part, to not knowing job-related terminology. In our original ATCBT design, each lesson had an individual glossary containing terms or acronyms unique to that specific lesson. Since many of our lessons are structured to build on one another, terms had to be duplicated in multiple lesson glossaries. This requirement created a significant workload for authors when editing or updating terms. The glossary function was redesigned so all lessons access a central glossary of terms. This saves time when performing edits or updates, and also contains many terms or acronyms not contained in ATCBT lessons. If students come across an unfamiliar term or acronym in a technical reference or during the course of duty, they can request a definition from the glossary the next time they take a lesson (Figure 5). Features such as those mentioned above increase the success of our training system, but to make it complete we must hold the student's attention and increase the interactive feature of CBT.

Increased use of screen masks with problem solving exercises have proven a successful tool for increasing interaction and learning for the students. One successful type of screen mask shows students the forms they'll use on the job with the relative location of required entries. This type screen mask is used during the training phase and allows the student to complete the form with information from a given scenario. During the testing phase, a second type screen mask displays a form used on the job and requires students to again make correct entries based on information provided. The use of such screen mask interaction builds student confidence in accurately completing required documentation and can serve as a media for providing group training on new or modified forms and procedures.

A second student interaction project under development relates to our available transportation computer systems. With the use of fixed prompt locations and scenarios, students will be trained on command line entries required to log on and perform computer system functions (Figure 4). Simulated databases will be constructed to interact with the scenarios, thus providing students with realistic results. Screen masks of available menus will be created to accurately depict the actual working computer systems. Students will be able to perform cargo and passenger processing and manifesting procedures on the ATCBT similar to those of the actual systems.

The ATCBT visual representations are a significant factor in its effectiveness. Through the use of enhanced graphics capability, students can experience true-to-life examples of job-related activities. The 4 color CGA "stick-figure" graphics we once used have been replaced by realistic 16 color images performing various tasks (Figure 6). Images and equipment are now life-like. The camouflage uniforms are detailed and in actual colors. This may seem like a modest improvements, but we find students can better relate these images to the task being performed and the work environment when the effect of realism is evident. Using an enhanced graphics capability affects not only graphics resolution and colors, but improves text

quality and allow greater use of screen masks. Designing an extensive graphics library can be time consuming, but with the right equipment, such as color scanners, you can reduce production time considerably.

A successful CBT system relies heavily on student-centered features and enhancements to maximize performance tasks. Features such as bookmark, page numbering, and page browsing provide students with greater control and flexibility. Also, an effective system reinforces material with frequent quizzes and repeat instruction if the question is missed. The ATCBT system can respond directly to an unfamiliar vocabulary inquiry through the availability of an extensive glossary of terms and abbreviations. Next, it encourages student interaction through the use of screen masks which simulate forms and computer systems used on the job. It also encourages the use of the students' thought processes and decision-making abilities through true-to-life scenarios. Finally, it contains an extensive graphics library to visually reinforce the material. With all these added features, the one question remained, "did the students in the field actually spend more time viewing and completing the redeveloped ATCBT lessons?"

Our converted EGA system with 66 lessons was loaded at each of our sites in April 1990. We analyzed lesson completion data for the 66 lessons for the periods of April through August in 1989 and 1990 to determine student acceptability of the new system. Our study showed an average monthly increase of 68 percent in the number of personnel completing the EGA lessons versus the CGA lessons. It could be argued that CGA system offered 138 lessons, thus affecting our analysis. However, when comparing lesson completion data for all lessons available on each of the systems, the upgraded EGA system still showed a 54 percent increase in lesson completion over the entire CGA lesson inventory. Furthermore, our analysis revealed there has been an average 40 percent increase in the number of supervisors, managers, and non-unit trainees completing the EGA lessons versus the CGA lessons. Considering an estimated 15 percent decrease in our career field manpower, analysis of available student usage data, and student comments from our sites, the EGA upgrade to our ATCBT was both positive and beneficial.

Faced with a limited staff and a seemingly insurmountable workload of upgrading lessons with the new enhancements discussed, we initiated a cost study on the feasibility of contracting the lesson revisions. All revision items were considered and cost estimates were based on reproduction hours. The study revealed the costs associated with lesson revisions were nearly equal to the development of a new lesson. Limiting factors to consider with contracting second party productions are their unfamiliarity with the technical content or references in lessons, limited knowledge of our lesson standards and screen formats, and time lost due to mailing materials between producers and reviewers. An alternative to contracting entire lesson revisions is to have a contractor only "rekey" a lesson in the authoring language. Screen prints of required text rewrites and redesigned graphics would be provided by the MDC staff. The cost of this approach is not final, but it's estimated to be one-third of the initial study's cost quote, but with the MDC responsible for a considerable portion. The third option is for our MDC staff to perform the entire lessons revision. This would require us to have a highly qualified, well trained, and sufficiently staffed pool of lesson developers which we do not have.

Lesson Developer Training

The ideal staff consists of the specialists one needs, in the numbers required to accomplish the workload, and provided with the equipment needed to maximize their productivity. Because we are a military organization, our staff has remained relatively constant and our budget has been constrained which precludes us from obtaining additional equipment immediately that would improve productivity. As stated earlier, the MDC has been staffed by six to nine personnel over the past two years with varied, but limited, experience levels. Personnel assigned to the MDC normally serve a three-year tour as a lesson developer and then return to their primary air transportation job. This poses a staff training problem as newly assigned personnel are often unfamiliar with

authoring techniques. To complicate matters, there is no Department of Defense (DOD) affiliated school providing instruction on our authoring language. Available non-DOD schools teach a myriad of other languages and systems with little correlation to each other or our ATCBT language. Hence, it became imperative to develop an MDC OJT program to maximize the productivity of the personnel during their short 3 to 4 years at the center.

The development of an effective OJT training program was not an easy task. Since we had no one experienced in ATCBT lesson development or the authoring language used, it was difficult to put together any type of training program. In the initial stages of ATCBT implementation, the staff directed its attention at getting sites up and running with the lessons being developed by a contractor. After the contract expired and as problems or inaccuracies were identified, it became apparent that our MDC staff would need to acquire the authoring skills in order to maintain the inventory of lessons. The ATCBT staff read books and articles on various aspects of computer operations, taught themselves, and then shared the information and skills with other staff members. Using this hit-and-miss technique, the staff achieved an acceptable level of efficiency to cope with the problems that arose. However, the staff soon realized a formal program to train future authors was needed.

The MDC staff set about organizing training requirements ranging from simple system command functions, such as disk operating system features, to the actual internal operation of the ATCBT and authoring environment. Training requirements were documented and an incremental training plan was established. Staff members were first trained on basic computer operations and equipment maintenance and troubleshooting procedures. Our second step was to train them on the use of various word processing, graphics, and hard disk management software packages. Finally, personnel were trained on lesson development using the authoring language. The overall methods of training were comprised of video tape instruction, user manual reviews, and actual hands-on demonstration and performance evaluation.

Selecting MDC personnel based on outstanding performance as an air transportation specialist did not always prove effective. Some of the initially assigned air transportation specialists found working with computers unchallenging and preferred to do formal classroom instruction. Hence several months were spent training personnel and receiving minimal results. Our only alternative was to redefine job prerequisites. By making a conscious attempt to recruit personnel who possessed some programming skills or had experience in computer operations, we have since reduced training time by 60 percent. Those individuals with computer experience require minimal trainer supervision and are self motivated to quickly learn our authoring language on their own. Along with an efficient staff of lesson developers, you must have an experienced staff of technical reviewers to ensure lesson accuracy.

Maximizing Staff Productivity

Producing a quality lesson requires the coordination of lesson developers and a technical review staff. Both are interrelated and work together to complete the final CBT lesson product. While it is desirable for authors to be qualified in all aspects of lesson development, this is not always possible. Some authors are better suited to make text and programming entries into lessons, while others are more skilled in graphics design. All authors undergo initial lesson development in both areas and their capabilities are evaluated. Their specific skills and preference determine if they are assigned as an author or graphics specialist (Figure 7). Because of internal motivation, their productivity is significantly enhanced.

As explained earlier, our new ATCBT lessons are reviewed for technical content by a subject matter specialist (SMS). Prior to 1989, lessons were distributed to various units or headquarters staff personnel for a SMS review. This process required the maintenance of an extensive SMS location list and required frequent updating since military personnel move approximately every three years. A key problem with using various unit level SMS personnel is the tendency for knowledge of localized procedures to conflict with command-level, established procedures. Due to the

availability of technical instructors at the training center and because the SMS review process was so time consuming, the program of tracking command SMS was discontinued. Instructors from the Intermediate Air Transportation (IAT), Intermediate Wartime Contingency (IWC), and Air Transportation Managers' (ATM) courses were readily available to provide the MDC the technical expertise for lesson reviews. Due to the three-year tenure of instructors, there is a constant turnover of personnel from various commands and theaters of operation which precludes bias during multiple reviews. Also, daily instructor and student interaction provides a valuable source of information relating to the actual conditions and changes occurring in the air transportation field. By utilizing these instructors, we have reduced the technical review process by an estimated 65 percent. Also at our disposal are experienced personnel locally assigned to the 60th Aerial Port Squadron. Their familiarity with the cargo and passenger computer systems is a definite advantage, and we are able to control the amount of local procedure bias during lesson review. The results are more technically accurate, better designed, and more interactive ATCBT lessons.

Each CBT program must be tailored around training needs, subject areas, and student capabilities. While there are no clear cut guidelines for CBT system development, we can offer suggestions from our experience to make your transition to CBT less painful. To complement your authoring software, you will need a well-trained staff of lesson developers and graphics specialists. Carefully screen prospective employees and try not to hire staff on a temporary basis to ensure continuity. Authors should be proficient in computer operations and language and have a better than average knowledge of English grammar to prepare effective and correct informational texts. Authors should be familiar with lesson content and have some job knowledge of the areas being developed. If a staff of subject matter specialists is used, attempt to recruit them locally to avoid "long distance" coordination with lesson authors.

<u>Conclusion</u>

The success of any computer based training system is a blend of the proper system and support equipment, user friendly lessons, and a trained and productive staff. If one rushes into developing a CBT program without thinking through all of its components, the program product will suffer the ill effects of impatience. In this paper, we have provided a brief overview of our ATCBT program, the hardware and software problems we experienced in its evolution, actions taken to solve them, and our suggestions on how you can effectively approach implementing CBT in your own environment. We also discussed positive lesson enhancements which can be incorporated into your system to make it more user friendly and reinforce learning. Finally, we considered the effective use of available manpower to achieve our CBT objective by establishing a comprehensive on-the-job training program and maximizing the use of in-house staff as subject matter specialists. Not all problems can be identified before system purchase and implementation. We hope this paper has provided you with a basis on which to evaluate your current CBT program or considerations to think about if you're desiring to enter the exciting world of interactive computer learning.

SUMMARY OF LESSONS LEARNED

<u>System Development</u>

- Thoroughly evaluate computer hardware requirements.
- Predetermine required lesson inventory and operating software.
- Select operating software common to the industry.
- Design lessons to the maximum capability of the equipment used to run them.

<u>Lesson Enhancements</u>

- Initially incorporate student oriented controllable features in your CBT.
- Include frequent review quizzes to reinforce learning.
- Use screen masks and true-to-life scenarios to improve training

effectiveness.

- Design lessons to react similar to actual computer systems or equipment.

- Use realistic graphics images to enhance understanding.

Lesson Developer Training

- Develop an effective development staff training program.

- The authoring system used should have an effective tutorial.

- First lessons designed should teach lesson development and standards.

- Utilize personnel knowledgeable in CBT development procedures, with computer experience.

- Try to avoid frequent personnel turnovers.

Maximizing Staff Productivity

- Organize CBT development into areas of authoring, graphics development, and subject matter review specialists.

- Have a readily available staff of *subject matter review specialists.*

- Structure an effective cycle for lesson review.

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Air Force Regulation 50-23, Enlisted Specialty Training. Washington DC: Headquarters US Air Force, 1990.

1. TASKS, KNOWLEDGE AND TECHNICAL REFERENCES	2. CERTIFICATION FOR OJT A Start Date	B Completion Date	C Certifying Official's Initials	D Trainee's Initials	3. PROFICIENCY CODES USED TO INDICATE TRAINING/INFORMATION PROVIDED A 3 Skill Level (1) Course	A 3 Skill Level (2) CDC	B 5 Skill Level (1) Course	B 5 Skill Level (2) CDC	C 7 Skill Level (1) Course	C 7 Skill Level (2) CDC
9. OPERATE VEHICLES/EQUIPMENT (CONTINUED)										
(7) 10K adverse terrain forklift					-	-		-		
(8) 25K aircraft loader					b	b		B		
(9) 40K aircraft loader					b	b		B		
(10) M-Series vehicles, such as M-1008, M-35A2, M-818, M-1009, and M-52					-	-		-		
(11) 25K TAC loader					-	-		b		
(12) -18 air conditioner (65 ton)					-	-		b		
(13) Wide-bodied cargo loader (such as 316A, 316E)					-	-		b		
(14) Lower lobe loader					-	-		b		
(15) Latrine Service Truck/Cart					b	b		-		
(16) Potable water truck					b	b		-		
(17) NF-2 Light cart					a	a		b		
b. Perform operator inspection/ maintenance on										
(1) 10K forklift					2b	b		B		
(2) Passenger bus					2b	b		B		
(3) 25K aircraft loader					2b	b		B		
(4) 40K aircraft loader					2b	b		B		
(5) Latrine service truck/cart					2b	b		B		
(6) Potable water truck					2b	b		B		
c. Perform as ground spotter TR: Appropriate Aircraft -9 TOs, AFR 76-6, AFM 77-2					2b	b		-		
10. RECORDS, REPORTS, FORMS, PUBLICATIONS										
a. Identify transportation manuals, regulations, and forms TR: AFRs 0-2, 0-4, 0-9, 0-10, 0-17, 5-31					2b	b		B		
b. Locate information in transportation regulations and manuals TR: AFR 75/76 Series; DODR 4500 Series; MACR 76 Series					2b	b		B		
c. Locate information in technical orders TR: TOs 00-20B-5, Appropriate Aircraft -1 and -9 TOs, 13A20-4-1, 13B4-2-1, 13C7-1-5, 13C7-1-11, 34D-2-2-2, 36M-1-141					-	-		a		

Figure 1. Speciality Training Standard Example

EQUIPMENT AT CENTRAL SITE

ITEM	COST PER UNIT
Z-248, with 360K and 20 MB Drives	1,960
20 MB Hard Drive	280
Color Monitor	300
Printer, LQ	573
Anti Static Mat	70
Surge Suppressor	20
40 MB Tape Drive	395
Computer Work Center	350
Dust Buster	70
Desk Chair	100
Halon Fire Extinguisher	50
Disk File Box, Locking	30
TOTAL	4,198

EQUIPMENT AT REMOTE SITE

ITEM	COST PER UNIT
Z-248, with 360K and 20MB Drives	1,960
20 MB Hard Drive	280
Color Monitor	300
Anti Static Mat	70
Surge Suppressor	20
Computer Work Center	350
Desk Chair	100
Halon Fire Extinguisher	50
TOTAL	3,130

NOTE

The figures shown reflect the government purchase prices for 1985 through 1989. They do not reflect current prices and do not apply to non-government agencies.

FIGURE 2. ATCBT EQUIPMENT EXPENSE AT EACH TRAINING SITE

SOFTWARE - CENTRAL SITE

ITEM	COST PER UNIT
CDSX	150
Control	200
Optimize	100
TOTAL	450

SOFTWARE - REMOTE SITE

ITEM	COST PER UNIT
CDSX Software	150
Control	200
TOTAL	350

NOTE

The figures shown reflect the government purchase prices for 1985 through 1989. They do not reflect current prices and do not apply to non-government agencies.

FICURE 3. ATCBT SOFTWARE EXFENSE AT EACH TRAINING SITE

At the prompt, type R for reservations, a 6-position MAC channel and a Julian date frame (3-position begin, 3-position end). Separate the items with semicolons (;). This command is used only for TDY requests.

For example, let's make the reservation for MAJ Morgan. She will need a reservation on MAC channel STLFRF with a Julian date frame 204 to 206.

Type: R;STLFRF;204;206 and press the transmit key.

F5	F7	F10	PgUp	Any Other Key
Glossary	Bookmark	Quit	Previous Page	Continue

```
$**$BRK[

RESV:
[--------------  NAME    [---          GRADE          ----FLIGHT  STATUS-----
[ØØ1             STS REQ[-             PAX CAT         MSN # DEP D/T CR OPN RSV ARR D/T
[STLFRF          CHANNEL[3             PRIORITY     A-NE41  276173Ø B  1Ø1 ØØØ 04 Ø8ØØ
[PU              TYP TVL[ Z            SPON SVC     B-NE41  278153Ø B  267 ØØØ Ø6 Ø6ØØ
[--              MONTH   [---,-,---/-TVL PERF       C-NE41  283173Ø B   22 ØØØ 11 Ø8ØØ
[-               MSN SLT[T             SOURCE       D-NE41  285153Ø B  143 ØØØ 13 Ø6ØØ
[--------        ROUT ID[----------    RIC          E-NE46  2891316 B   99 ØØØ 17 ØØØØ
[-/-             SH/SP   [M/-          TRAN/N AVL   F-ME41  292153Ø B  146 ØØØ 2Ø Ø6ØØ
[---------------CIC      [-,-,-/-,-,-PET S/W/C      G-602XX 2931ØØØ YG   1 ØØØ 21 Ø74Ø
[-------         MSN NBR[---,---       DP D/T-L     H*462X1 2941246 YG   3 ØØØ 22 Ø64Ø
                         [-            EXC BAG      I-NE46  2691316 B   16 ØØØ 24 ØØØØ
[---             ORG STN[---           FIN DES      J-NE41  299153Ø B   61 ØØØ 27 Ø6ØØ
[-,-             FB/R OV[--            SVC USE      K-NE46  3Ø31316 B  132 ØØØ 31 1ØØØ
```

A split Reservation Mask will appear on the screen. Up to 13 flights on the MAC channel and within the time frame you requested will be displayed under FLIGHT STATUS.

F5	F7	F10	PgUp	Any Other Key
Glossary	Bookmark	Quit	Previous Page	Continue

Figure 4. Menu Options and Screen Mask

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Let's step through each key in a DD Form 1387-2 to see where the data comes from so you will know where to go to verify its accuracy.

Type in the word you want defined...aerial port of embarkation

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Let's step through each key in a DD Form 1387-2 to see where the data comes from so you will know where to go to verify its accuracy.

(APOE) - A STATION WHICH SERVES AS AN AUTHORIZED PORT TO PROCESS AND CLEAR AIRCRAFT AND TRAFFIC FOR DEPARTURE FROM THE COUNTRY IN WHICH LOCATED. Is there another term you would like defined? (Y/N)

Figure 5. Glossary Input and Response Screens

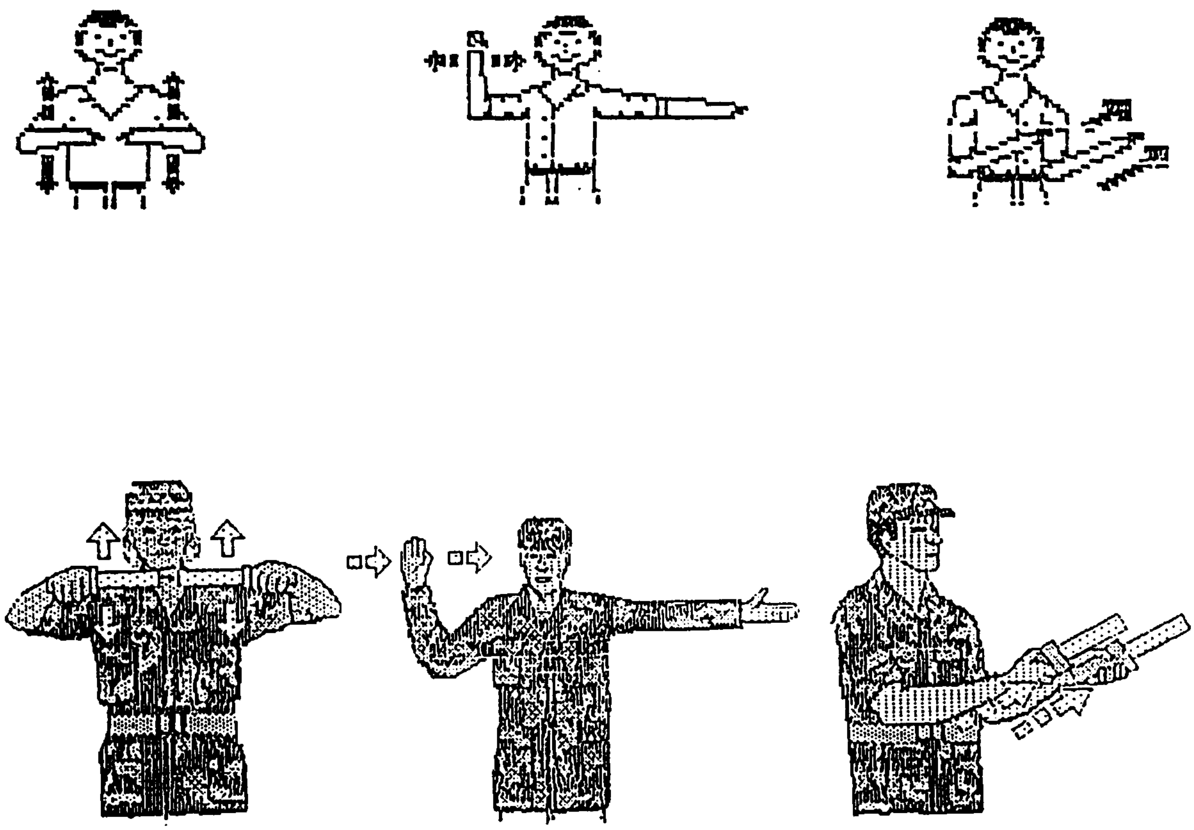

Figure 6. CGA versus EGA Graphics Comparison

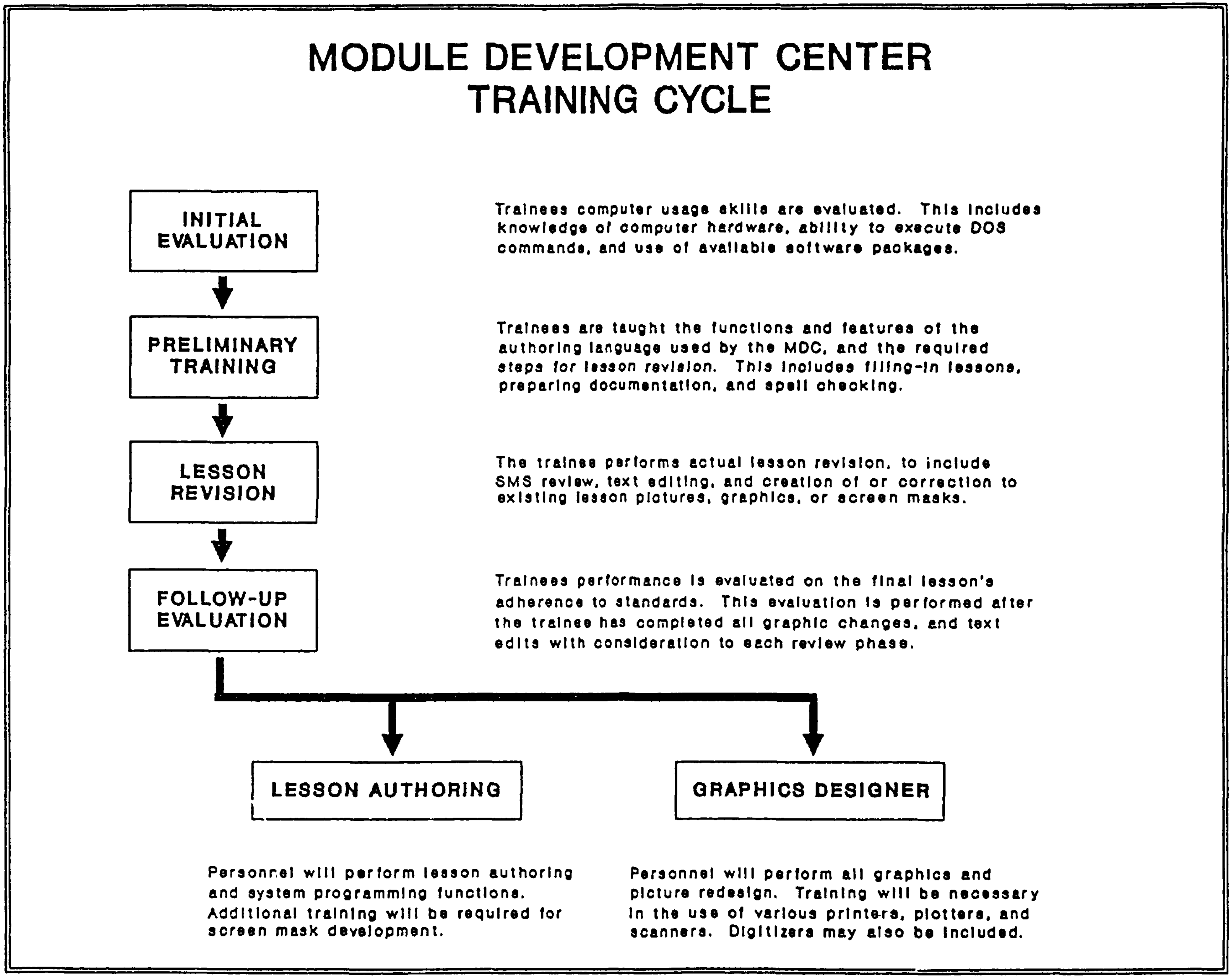

Figure 7. Module Development Center Training Cycle

CONSIDERATIONS IN PLANNING FOR EXPORTABLE INTERACTIVE COURSEWARE (ICW)

T. Kent Thomas

Exportable training, providing training to the trainee when and where it is needed, offers significant promise to meet the challenges of increased training requirements and decreased training resources. Just as today's economic changes call for significant shifts in the way we do business, such as increasing the use of exportable training, the use of exportable training brings a "new set" of considerations and issues into play. The challenge of implementing an exportable training program is further compounded when using newer training technologies such as interactive courseware (ICW). The author will present some of the issues addressed by Tactical Air Command (TAC) in implementing and managing an exportable ICW training program for aircraft maintenance continuation training.

Considerations addressed include purely planning factors, such as hardware availability, compatibility and configuration; hardware location and management; distribution media and methods; and courseware configuration control. Courseware design requirements, trainee and manager instructions for using the courseware, and computer-managed instruction (CMI) requirements also warrant special consideration.

Lessons learned from this innovative use of training technology have widespread application to others considering exportable ICW, regardless of any differences in training requirements, subject matter or target population. While exportable training using ICW holds significant promise, it is quite different from the use of ICW in a resident, closely supervised environment. To capitalize on the potential, managers must recognize and address these differences - from conception through implementation.

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CONSIDERATIONS IN PLANNING FOR EXPORTABLE INTERACTIVE COURSEWARE (ICW)

T. Kent Thomas

Introduction. ICW can provide an increased volume of training with a decreased number of instructors and support equipment. The actual course content is presented by the training system, not via an instructor's lecture or demonstration. If the courses are designed accordingly, the systems can be used in a "stand-alone" mode, requiring little or no supervision. The computer can also do most of the training management functions such as recording grades or making assignments. Incredibly large economies of scale are possible using ICW, since the training systems are relatively inexpensive, "transparent" to the course content, and courses can be inexpensively reproduced in large quantities. Consequently "exporting" ICW to the students, instead of sending the students to the school, has significant potential.

Assuming that the training requirements have been thoroughly analyzed and ICW is an appropriate media, several other factors should be considered before deciding to use exportable ICW. The new AFP 50-68, *Information for Designers of Instructional Systems,* Volume V, *Interactive Courseware (ICW) Decision Guide,* now provides some excellent guidance on considerations for exportable ICW. This discussion follows the general sequence of the decision aids in AFP 50-68, Vol V, expanding on what we consider the most crucial factors based on our experience, as briefly described below.

Tactical Air Command (TAC) is currently developing an extensive continuation training program for aircraft maintenance technicians using exportable ICW. The interactive videodisc (IVD) training systems are in learning centers located in/adjacent to maintenance workcenters. They provide refresher and advanced training on a time-available (i.e. opportune) basis. More than 330 IVD systems are installed throughout the world, supporting over 30 courses, primarily for the F-15 and F-16 aircraft. More than 30 additional courses are under development.

The 4400th Maintenance Training Flight (MTF) was activated to provide TAC's "in-house" IVD development and management capability. Initially the 4400 MTF developed nine courses for existing F-15A/C model aircraft. However, that role has rapidly changed to primarily defining and managing ICW development contracts, plus maintaining and updating courses provided through the weapons system acquisition process or other contracts. This approach ensures as rapid an initial development as feasible, responsive courseware updates to maintain configuration control, and minimal contractor dependence.

Having determined that ICW is an appropriate media and there is a potential application for exportable ICW, you should thoroughly research that potential. ICW and training systems are expensive, so there are large risks associated with this decision - from purely a cost perspective. Let's examine in detail some specific considerations when making this decision.

Existing Hardware Systems. Obviously, you should determine if there are training systems available to support the ICW. Even though microcomputers are becoming widespread, do not assume that they will be available to run the courseware. Instead, conduct an in-depth survey of the potential training sites. You should be very familiar with computer systems, or you must get someone who is to help you.

Defining Existing Systems. Determine the specific type(s) and number of machines available, including their exact configuration ((operating system, amount of random access memory (RAM), number and size of storage devices, all peripherals, type of graphics card and monitor, available expansion slots, etc.)) For example, there are still numerous Z-100 computers in the Air Force which are not compatible with the later, more common Z-248 computers unless they have been upgraded with a Gemini board. Even with Gemini boards, almost all Z-100s are monochrome systems

which limit their capability as a training pl..tform. The individual Z-248s may also have different graphics cards (EGA or VGA). The Unisys computers from the Desktop III contract can also have different graphics cards. *Graphics capability is the largest single contributor to ICW incompatibility.*

Next, determine how many vacant expansion slots are in each computer, in case expansion becomes necessary. Since most ICW, like most software, is distributed on floppy diskettes, determine what type of floppy diskette drives the systems have? There are at least two common formats for both the 5.25 inch and the 3.5 inch diskettes. You'll want to avoid distributing the courseware in multiple formats if all possible. Do the systems have or do they need modems to communicate with your computers to upload or download lesson or student files?

Defining Their Availability. Determine how the systems are currently being used, when, how often, for how long, and by whom. The hardware simply may not be practical for use as a training system due to the level or priority of current use. For example, the available storage on the hard disks may be insufficient for your ICW. Or, the potential students would be frequently interrupted by "priority" users. Is the system available when the students will be, when the training needs to occur, or is it in a locked office? Consider the amount of time the systems would be available for use by students. Multiply the estimated time for a student to complete your ICW by the anticipated number of students per site. Is there sufficient time available for training during the required period? Don't forget to consider the impact of personnel turnover in this computation. You can also reasonably expect that computer use for their other intended functions will increase, so allow for some "growth."

Is the hardware physically located where the students will be, or will the students need to go to a different location to use the system? The requirement to travel even a short distance will likely reduce utilization of the ICW. Note that one of the strengths of exportable ICW is the potential use right in the workcenter. The students can use the system on an opportune, time-available basis when the workload permits. They can be easily monitored to ensure training time is spent productively. Assistance is readily available, should they have questions or problems. Training can be quickly stopped, if needed, and the students returned to work promptly. If the students must travel to use the system, the local manager will sacrifice both convenience and control.

Determining Necessary Expansions or Modifications. If the systems are available and the location is conducive to training, determine if any modifications or expansions are necessary. Some modifications are likely.

Are additional input devices required, such as touchscreen, mouse, track ball or light pen? Be aware, all mice are not compatible, most track balls operate like an upside down mouse, and some monitors cannot be readily modified to add a touchscreen. You should also ensure that the available or selected input device(s) are compatible with the selected authoring system. Note that most ICW authoring systems will allow either multiple input devices or the selection of different ones. However, this may require significant time and effort, and may not be readily done at the training site. So, this might require distribution of two or more different versions of the ICW. Some authoring systems support more different types of input devices than others and all input devices are not created equal. Mice are generally the most accurate pointing devices, followed by the keyboard, light pen and touchscreen in that order.

As a general rule, ICW developed for a less accurate input device can be adapted for a higher accuracy input device, but not vice versa - without a significant amount of effort. Ease of initial learning and continued use should also be considered. Mice and track balls may require some initial student orientation, for both hand/eye coordination and how to make selections by "clicking the correct button." Both light pens and touch screens use a natural pointing motion and are easy to learn to use. But, students will likely complain of tired arms when required to touch the screen for extensive periods of time. Keyboards require some typing proficiency or the students will likely get frustrated - initially learning the location of all

the keys and the functioning of special control or function keys can be overwhelming.

Are color monitors and color graphics cards required for any system? Note that monochrome systems are appropriate only if there are virtually no complex graphics required in the ICW. They cannot support still or motion video. Do any systems require printers to print necessary training reports? Do any need additional storage devices? Are additional expansion slots or communications ports required to connect the input devices, printers, or storage devices? Be sure to identify all required connectors and cables also.

ICW Presentation Features and Supporting Media. Before you can make specific hardware determinations, you must thoroughly evaluate the ICW presentation features required to support your training requirements. These presentation features are the primary determinants of the specific hardware configuration and the authoring system you'll need. Presentation features also drastically impact the amount of computer file storage required, a primary dèterminant of distribution medium.

Audio. If audio is required for the ICW, note that digital audio requires very large amounts of storage space. Digital audio is not really practical for distribution via floppy diskettes or for use on average-sized fixed or hard disks. Note also that most vendors' digital audio cards use a proprietary file storage format that is incompatible with those from other vendors. You will likely need to purchase the same type of digital audio card for all the training systems.

Before deciding on any specific audio card, ensure that it is supported by several different authoring systems (unless you've already decided on an authoring system). Since most digital audio cards are relatively inexpensive and provide very similar capabilities, you should select the authoring system first, then select an audio card that it supports. Verify that your computer monitors have built-in speakers. If not, you will need to add peripheral speakers or headphones. You'll also likely want some type of optical write once, read many (WORM) or laser ((either videodisc or compact disk (CD)) type drive to support adequate quantities of audio. Similarly, if many high-quality visuals will be needed in the ICW, you'll likely need a WORM or laser type drive. You may also need a higher resolution graphics card.

Visuals and Audio Using Videodiscs. Laser videodiscs are commonly used to store large quantities of visuals and audio in an analog format, with 54,000 video frames and 60 minutes of monaural audio per disc side. If you intend to use videodisc, you will likely need to add both a graphics overlay (i.e. genlock) card and a videodisc player to each system since interactive videodisc (IVD) systems aren't all that common. If some IVD systems are already installed, ensure they are compatible, or plan on replacing at least some components. Note that some vendors offer both color graphics and graphics overlay capabilities on the same card, while others use a two-card set.

Since the color graphics card is the most common source of incompatibility in IVD systems, this is an excellent opportunity to increase compatibility by replacing some of the existing graphics cards. But, make sure the type you are considering is completely compatible with both the existing computer hardware and software. Similar to specifying a specific printer during the initial setup of a word processor, some authoring systems and languages allow you to specify different graphics cards when you develop the ICW. However, most will not allow you to change the ICW to specify a different graphics card once the ICW is developed.

Most ICW authoring systems or languages allow you to easily specify different videodisc "drivers" to support the common models of videodisc players. However, this may or may not be easily accomplished at the training site, once you have developed the ICW. It depends on the specific authoring language or system.

Most videodisc players use a standard Laservision 8-inch or 12-inch storage format, so incompatibility is usually not a problem with the videodisc itself. There are other less-common, incompatible videodisc formats used by some vendors for their "one-time recordable" discs. While beneficial for ICW prototyping and development, these optical media-directly

recordable (OMDR) formats are not frequently used for student stations due to the high per copy cost of each videodisc. In contrast, Laservision-format videodiscs are mass replicated at a much lower cost per copy, when done in quantity. The OMDR videodiscs cannot be mass replicated.

Even with Laservision videodisc players there are several proprietary (i.e. incompatible) features that can be used either in recording the videodisc (i.e. digital audio tracks, still frame or compressed audio, or digital data) or when authoring the ICW (i.e. "instant jump" features, video frame buffering, etc.). While some of these features are enticing, especially digital audio or data, weigh their value against the inherent incompatibilities very closely.

Avoiding the use of these features and using only the standard Laservision features will ensure compatibility of the ICW with all Laservision videodisc players. As a final note on compatibility of videodisc systems, be aware that many of the newer computer monitors do not have speakers built in. When adding videodisc, it may be necessary to plug headphones or a small set of amplified speakers into the headphone jack on the videodisc player.

Visuals and Audio Using Compact Disks (CDs). The smaller, 4.72-inch laser-read CDs are similar in form to videodisc, but use a variety of digital formats, each with its own acronym and intended use, including CD-ROM, CD-A, CD-ROM/XA, CD-I, DVI, etc. This storage technology is changing very rapidly and a definitive discussion of the different formats is far outside the scope of this paper. There are several general considerations of CDs that are relevant, however. CDs are less expensive to replicate than videodiscs, and the CD drives are also less expensive than videodisc players. CDs can store very large quantities of digital information, either data, audio or visuals for ICW presentations. All require a CD drive and some type of interface card in the computer, other than those normally used for hard disks and floppy drives. Make sure you understand the different formats thoroughly before deciding to use CDs.

CD Compatibility. When storing only data, the CD holds approximately 550Mb, and is usually compatible with all CD-ROM drives, which are normally found only in computers. As of the date of this paper, any CDs that are recordable and erasable are not compatible with standard CD-ROM drives. While some CD-ROM drives will also play the CDs used for home stereos (CD-Audio, OR CD-A), CD-A drives will not play CD-ROMs. If you can play a CD-A disk on your CD-ROM drive, headphones or amplified speakers plugged into the headphone jack on the drive itself are often required, since there may be no provisions to send this audio into the computer or out of any speakers in the monitor.

Audio can also be stored on a standard CD-ROM in several different levels of quality by using an audio digitizing card in the development computer and a digital audio card in each training system. While this allows you to store a mixture of computer text, graphics and audio on the same CD-ROM, the file format of the audio files may be incompatible due to different vendors and their proprietary formats for the different digital audio files, as mentioned previously.

Before deciding to use CDs to store or distribute your ICW, you should again ensure that the authoring system(s) support it. As of the date of this paper, many do not. CD-ROM/XA is a relatively new attempt to address this incompatibility by standardizing the audio cards and file formats for this media mixture, using the standard CD-ROM format and adding standard extensions for audio. CD-ROM/XA uses an additional interface card that may combine these two functions, control of the CD drive and decoding the audio. CD-ROM/XA disks will not play audio on systems with just standard CD-ROM drives, such as those available on the Desktop III, unless an additional audio card is added. ICW authoring systems or languages that fully incorporate CD-ROM/XA are presently very limited.

Constraints of CD-ROM. All CD-ROM disks have the potential to store very high quality still visuals, either those drawn via computer graphics packages, or digitized images from a scanner or video camera. Since these are truly digital images, a special overlay or genlock card is not required in the computer as it is for videodiscs. Note, however, that the

graphics card in the computer must be capable of displaying at least 256 simultaneous colors in order to provide acceptable-quality digitized, color images. This may require that you either add additional memory (VRAM) to the existing graphics card or replace it, and perhaps the monitor also if it was an "old" graphics card. Also, note that the higher the quality of the visual in terms of lines of resolution and number of colors, the slower the picture will "paint" on the screen. Also, access time for all CD drives is much slower than either hard disks or floppy diskettes.

Before deciding to use CD-ROM for your ICW, test the speed of CD-ROM graphics on your "target" system. You'll likely find that while CD-ROM can be a very efficient distribution medium, it may not be practical to operate the ICW directly from the CD. You may need to copy the ICW onto a hard disk first, to provide adequate computer response time. If so, make sure the hard disks are large enough with enough "free space" to hold the ICW. Digitized images are huge!

Motion Video on CDs. When it comes to motion video, the CD formats are even more dynamic and confusing. There are at least two CD formats that store motion video, as of the date of this paper. These are Digital Video Interactive or DVI and Compact Disk Interactive or CD-I. DVI is a proprietary product of Intel Corporation and can be added as a set of boards to MS-DOS microcomputers. DVI can play full-screen, full-motion (i.e. 30 video frames per second) video, though it is currently limited to 240 lines of vertical resolution. CD-I is a published standard by Phillips and Sony, and should soon be widely marketed by several vendors as a "closed system" that contains its own computer, graphics card, etc. CD-I cannot be added to an existing microcomputer, nor can it currently provide full-screen, full-motion video (though it should be available before the product is actually marketed).

There are "rumors" of further CD-ROM/XA extensions that will support full-screen, full-motion video - while motion video in a small part of the screen has been demonstrated. Other products have been announced that either can play partial-screen motion video or full screen motion at less that 30 frames per second. Authoring systems for any of these motion video CD formats are scarce, if available at all. Developers also report at least twice the development time required as for videodisc. If you think you may want to use CDs and your ICW requires motion video, evaluate the technical qualities of the system (lines of resolution, number of simultaneous colors, frame speed of the presentation, size of the video on the screen, etc.) very, very closely. Also, potential incompatibilities abound due to the different formats. While these technologies hold very significant potential, there will likely be "format wars" similar to the recent one in consumer videotape formats. Are you sure that you can "pick the winner?"

Other Considerations Impacting the Storage and Distribution Medium.

Though the ICW presentation features required are the primary determinants of the storage and distribution medium, other factors impact this decision. The primary ones are how many copies of the ICW are needed and how often will the ICW be updated. The remaining factors may be important in your specific training environment.

Permanence Versus Updates. Currently almost all the very large capacity storage media are essentially disposable. If they can be reproduced in quantity economically, they cannot be erased and reused. For example, erasable CDs have been announced and there have been "rumors" of erasable videodiscs for years - none are currently available in standard formats. (There are currently large capacity magneto-optical disks that can be erased and reused, but they are relatively new, incompatible from vendor to vendor, and there is little software or authoring system support for them.)

Some formats such as WORM or OMDR disks can added to, by recording additional information, but the original information cannot be changed once recorded. They offer increased flexibility for prototyping, initial development, and updates - but the media is more expensive per copy and they cannot be mass replicated. So, you must carefully consider both the initial development costs, flexibility required, cost per

copy in volume (including any mastering fees), and the amount of updates anticipated.

If updates will not be frequent, the "permanency" of the recorded medium is not very important. If flexibility is important and updates are frequent, the WORM or OMDR formats are cost effective in small quantities. If large quantities are required, you should either use a CD or Laservision videodisc and plan for updates. CDs are usually "re-replicated and replaced," due to the low cost per copy. ICW using Laservision videodiscs can usually be updated via changing the software stored on floppy diskettes - up to a certain point, then replication of a new videodisc is required. (Note that if the computer software that controls the videodisc is also stored on the videodisc as digital data, you may not be able to update it using floppies. Replication of a new videodisc may be required - another reason, besides incompatibility, to avoid this practice.) In any case, plan for the updates that will be required and consider the continued mastering and replication costs when making your decision.

Type of Use. How the ICW will be used by the student also impacts the media consideration. Must all the courseware be loaded and resident on the training system at all times? This determines the volume of storage needed "on-line." Or, can the ICW be loaded as required? If so, how long does it take to load it? How fast must the storage device be accessed to find and present the next screen to the student? Hard disks are the fastest, followed by floppy diskettes. Far slower are videodiscs, WORMs and CDs, not necessarily in that order. Note that the "geography" of the physical location of the information on the disk and the way it is indexed in order to find it are prime determinants of access time. For example, if the next video still that is needed from a videodisc is located very close to the current one (i.e. plus or minus 100 frames or so) the access time is virtually instantaneous. If it is located at "the other end of the disc" it can take one to three seconds or more.

With CDs the index is crucial, and the time for the screen to "paint or draw" is also a factor. In any case, you will likely want to "mix" the distribution media, by using floppy diskettes to distribute the control software, with the audio and visuals stored on a CD or videodisc. This media mix significantly increases the ability to make quick, easy and cost-effective updates. The floppies can be loaded to the computer's hard disk, if desired, and the CD or videodisc "swapped" by the student when needed. Systems that contain multiple CD or videodisc drives, or simply store multiple disks and change them automatically when needed (often called jukeboxes), are also available. But, they may be cost-prohibitive and/or not supported by your authoring system.

Distribution-Only Media. Some storage media are appropriate only for distributing the ICW and cannot be readily used to present the ICW to the student. Magnetic tape or tape cartridges, regardless of the specific format, fall into this category since they either are not random-access or the access times are prohibitively slow. They also wear and become unreliable. Remote communication via networks or modems has virtually fallen into this category, given the advent of low priced microcomputers and the increasing costs of telephone or other communications lines. Remote communications can be very effective to distribute ICW and to report student data, but are being used less and less to actually present the ICW.

ICW Configuration Control. A potentially crucial consideration is the configuration control of the ICW at the training site. You must address the issues of what happens to the ICW once you identify that a change is required, and how you will implement that change. For example, is there potential for a change in a practice or procedure that may cause harm to the student or damage to equipment if the student is trained incorrectly? If that is the case, you must have provisions to either remove this training material from the system or block access to it as soon as possible. If the change is important, but not quite as critical, you can simply notify the student of the change and perhaps make them acknowledge it - similar to reading or posting an errata sheet for written materials. Other changes may not even warrant notifying the student. Whatever the case, you must have provisions to make these changes while retaining as much pertinent student data and student status in the ICW as possible. We have required field sites to return videodiscs to

us while we developed a change in the ICW, just to make sure that unsafe training did not occur.

Change in Student Status. A change to the course content may impact the training status for students that are currently "enrolled" in the ICW and students who have previously completed it. For example, some changes may be significant enough to require the student to repeat the particular section of training even though they had previously completed it. Or, it may require that only the students that are currently enrolled must repeat it in order to get "credit" for the new version of the course. Or, the changes may not impact student status at all. Regardless of the criticality of the change in the ICW, you also need to address provisions to ensure that only the most current version of the course is in use. All these issues should be addressed when considering the distribution or storage media. If the ICW is being completely stored on a hard disk at a remote site, can you know for sure that previous versions were destroyed and only the current version is available?

Replication. Who will replicate the ICW, including all printed adjunctive materials? CDs and Laservision videodiscs must be commercially mastered and replicated, if large quantities are required. Is there an existing requirements contract for replication or must a contract be completed each time? This impacts both price and lead time. OMDRs and WORMs can be locally replicated, but each one is essentially an "original" copy recorded in real-time, so it is very time consuming. Hard disks, even removable ones, are fast but are not usually practical as a distribution medium due to cost. Each copy would then be an "original", recorded one at a time. Magnetic tapes of any format are inexpensive, very slow to copy, and must be copied one at a time. High speed replicators for floppy diskettes are readily available and inexpensive. Or, you can have them replicated commercially.

If the ICW will be distributed over communications lines, there will be no direct replication required. But, a "bulletin board service" including a computer system, software, and someone to "tend and maintain it" may be required. There will likely be communications costs, if only a one-time cost to buy the network interface cards or modems required. Use of commercial phone lines would add a recurring cost. Regardless of what media you plan to use, be sure to address replication requirements. Obviously, the greater the number of copies of ICW distributed, the greater the potential impact.

Replacement Due to Damage and Wear. Finally, how durable is the media? Consider also the fragility of the media and its susceptibility to damage. You should also consider any required replacement of the media due simply to wear. For example, CDs and videodiscs that have been mass-replicated are very durable, though they can warp or break, and are not susceptible to wear. Those produced by direct read after write (DRAW) technologies are more fragile, can wear, and deteriorate over time due to exposure of the recording media to light and air. With continued use, replacement at some point is inevitable. Or, consider floppy diskettes. The 3.5 inch diskette protects the recording media with a shutter that automatically closes upon removal from the computer. The 5.25 inch floppies leave the recording media exposed and susceptible to accidental damage and increased wear due to dirt, dust, etc. Regardless of how the ICW will be replicated, be sure to include all replication costs (money and time) for initial distribution, replacement and updates in your media considerations.

Packaging, Storage and Distribution. The final consideration deals with the packaging, storage, and distribution of the ICW. Is the packaging readily available? Does it adequately protect the ICW during shipment and storage? Is a "bench stock" of stored ICW required for quick shipment or can it be replicated as needed? For example, mailers are readily available for shipping floppy diskettes and storage isn't a real problem. They can be replicated as needed from master copies that are safely stored.

On the other hand, both CDs and videodiscs require payment of a fairly expensive mastering and setup fee each time they are replicated - or you must pay the replication contractor to store the master copy in their protected environment, then pay only the cost per copy. Most people

try to anticipate their future needs, then replicate and store enough "bench stock" initially to meet their anticipated requirements. In comparison, WORM, DRAW or OMDR technologies allow you to replicate when needed, but you incur both the setup and replication time, in addition to having to store these fragile media in their protective covers in a suitable environment. Consider any costs associated with packaging and storage for the potential media, including both storage space and environmental requirements. The differences in actual cost of shipping the different media will not likely be significant enough to warrant consideration unless the volume of shipments is very high. Note, however, if the ICW is distributed via communications systems there are no shipment costs other than any recurring communications charges.

Final Note on Hardware. In summary, both hardware availability and compatibility are interrelated and critical since you will have to develop the ICW to operate on the "lowest common denominator" of hardware systems. That is why you must carefully and concisely define the common denominator - and what equipment expansion or modification is required for existing systems to bring them up to a new common denominator that will meet your training requirements.

Make no assumptions and take nothing for granted, especially when dealing with compatibility. For example, we selected and standardized on a particular brand and model of IVD system to ensure compatibility, since it offered a relatively simple, integrated system. But, we've been forced to make updates in some ICW because the manufacturer changed the version of the basic input-output system (BIOS) chip in their computers in the middle of a production run, even though everything else remained the same. Only after the ICW was implemented in the field did we discover the ICW operated just fine with the older BIOS chip, but there were intermittent errors when operating with the new BIOS chip. Consequently, we now thoroughly test all the ICW on three different configurations of the vendor's systems prior to shipment.

Courseware Design Requirements.

The design of exportable ICW is more complex and challenging than that of ICW to be used in a classroom environment. You must plan for minimal assistance to be available to the student at the training site, and design the ICW accordingly. Consequently, exportable ICW will likely require greater design and development time.

Comprehensiveness. First, the ICW must be "self-contained" as much as possible. Documents such as technical orders or job guides, that you can safely assume will be available at the training site, can simply be referenced in the ICW. However, they should be treated as reference material only - you probably shouldn't require that they be used in order to complete the training. Otherwise, if those reference materials are being used elsewhere at the training site, no training can be accomplished. If any other type of written or other adjunctive materials are required for the student to complete the ICW, then they should be developed and distributed as a package with the ICW.

Evaluate very closely any requirement for "expendable" documents such as workbooks that must be completed by the student. They require that someone at the training site reproduce (unless you provide them), stock, and issue them to each student. Further, they are easily lost or misplaced by the student, which can cause delays or "missed opportunities" for training. The student will naturally be reluctant to get another workbook and start all over, should they forget or misplace theirs. As a general rule, any increase in administrative workload placed on management at the training site will likely decrease the utilization of the ICW.

Further, the ICW must contain more helps, hints, glossaries, etc., than ICW used in a classroom. There will not be an instructor or anyone else to supervise the trainee at all times, providing assistance and answering questions. Similarly, more extensive explanations will be required in the ICW, especially for remediation or feedback to incorrect student responses. You should try to anticipate potential student

questions and mistakes and design provisions for them in the ICW.

The ICW must also be both more diagnostic and more prescriptive. There will be no instructor to evaluate the students' progress and prescribe further training, review or remediation. You cannot count on the supervisor or trainer to be actively involved in managing the student's training either. Diagnostic pretests and frequent review exercises or progress checks should be a standard part of your instructional design. Your ICW design should be preemptive, trying to diagnose and prevent the student from making mistakes as much as possible, rather than dependent on later evaluation and remediation.

Complexity. Meanwhile, you must also plan for the students to have a greater range of entry-level expertise and knowledge and include accommodations in the ICW. The relevant work experience of the students will likely vary much greater than those sent to classroom training, especially initial skills training. For example, even though you may direct course prerequisites and diagnose their mastery in a prerequisite test, how will you treat the student who has already completed the course and wants to merely review a section or take it as a refresher? You definitely do not want to discourage this type of utilization, since it is one of the unique strengths of exportable ICW. Instead, you should design provisions for multiple paths through the ICW based on pretest scores or their progress through previous material.

As a general rule, it is more desirable to present the student with "too tough a challenge" initially than to bore them with material they already know or that's too simplistic. If you overestimate the student's entry-level knowledge, you can still identify their weaknesses during subsequent progress checks or review exercises and provide remediation. On the other hand, if the trainee is bored by the ICW being "too easy", you may never know it unless it appears in course critiques or indirectly in low ICW utilization. Challenges can be motivating - boredom is almost always demotivating!

It should also be very easy for the student to skip material that they have already mastered or that is redundant. However, research indicates that the students may not be qualified to best assess their own capabilities or to determine a sequence of training. You should give the students as much freedom of movement within the ICW as possible, yet their instructional sequence should be determined by proven mastery of prerequisite material. Students should then have virtually total freedom to review the sections of the course as desired, once they have satisfactorily completed it.

Impact on Development Time. All these factors relate to ICW design, development and validation time. It is time consuming to analyze the subject matter to the point of determining common mistakes for different levels of skills and knowledge, then design provisions for them. It's time consuming to develop multiple paths through the ICW, when most students will not see them all and many will progress along the shortest path. Yet, all paths must be thoroughly tested and "de-bugged." Further, it is time consuming to validate the accuracy of your diagnostic tests and the appropriateness of the instructional prescriptions. Similarly, the relevance and effectiveness of the remediation may be difficult to validate since you must compare the type of mistake to both the actual and anticipated cause for the mistake. The mere existence of multiple paths means that more students will be needed to "try out" the ICW in order to validate all possible paths. As a general rule, an increase in ICW complexity results in exponential increases in design, development and development time.

User-friendliness. This overused term relates to the student's general impression of the training session, how they relate to both the ICW and the hardware, and the entire strategy or philosophy used to create the ICW.

Exportable ICW must be more user-friendly, since assistance and support is not readily available on site. Some aspects have been previously described, including both hardware and courseware that are easy to learn to use, adaptability of the ICW to the individual student, and a design intended to prevent and preempt student mistakes. Other aspects include accuracy, consistency, reliability and predictability of the ICW's appearance and

operation. It applies to more than the courseware itself, but also the hardware system and any supporting documentation.

The students should always know what to expect and should feel that they are in control of the training system and the ICW - within the limits of the instructional prescriptions based on their performance. The goal is to have the students so comfortable with the system that they are no longer conscious of the hardware or how they are interacting with it. It becomes almost second nature. Their entire focus can then be on experiencing and assimilating the course content. That content should ideally be presented so realistically that the student can "suspend their disbelief", and "get into it". The true power of multimedia is it's ability to address multiple senses simultaneously, thus increasing the realism almost exponentially.

Design Strategy. How is this emphasis on user friendliness implemented? At the macro level, the course must be at least somewhat adaptive to the individual student, providing a relevant and realistic training experience. At the micro level, each interaction should be carefully designed to "draw the student into" the training and encourage them to interact with the content, not the training system. The ICW should respond accordingly, in a friendly, conversational way. The response should be appropriate, accepting, and encouraging. Imagine a conversation with another person whose response to each of your statements makes little sense in this context, who intimidates you with their "know it all" tone, and who will volunteer little, responding only to your direct input, while pointing out each and every little mistake. Not really a conducive atmosphere for learning, is it? Yet that is exactly how much ICW is designed. Or, the ICW is simply an automated and perhaps illustrated book that the student mechanically pages through, answering occasional questions. "Page turners" are fully deserving of their notoriety!

The most effective ICW designs require an immense attention to detail at every step. Each screen, each interaction is carefully designed and created, then painstakingly assembled and tested. Once assembled, it is evaluated holistically, ideally by "outsiders". What theme does it contain? What tone or mood does it present? How does it look and feel? Does it seem real? What impressions are you left with? What strikes you about it, both positively and negatively? Etc.

Documentation. This same attention to perceptions and detail apply to the development and testing of the documentation also. Do not rely entirely on "on-line help, documentation or tutorials." What happens when the ICW fails to "boot" or start up, so these features are not accessible? There should always be a "quick reference" guide on paper included with the ICW, even if most of its content is duplicated in the ICW. In case of questions, it is often far easier to "look it up in the book" instead of loading and starting the ICW to review it. At the same time, the documentation should be short, clear and concise. Unnecessary detail discourages use and "hides" any truly needed information.

Develop the documentation carefully and validate it, just as you do the actual courseware. The documentation should address two separate audiences, the student and the manager (be it the student's supervisor or someone in charge of training). Both need to clearly understand the content, basic structure, objectives and performance standards of the ICW. Both need to know how to start the ICW, be aware of common problems encountered with either the ICW or training system, and know how to deal with them. Both need to know what individual student reports are available from the system and their basic content.

The manager also needs to know how to access any student summary reports provided, and their content. If the ICW is to be stored on a hard disk, the manager needs to know how to load and unload it. The manager also needs to know how to perform basic "file maintenance" on the ICW, making backup copies as required, plus how to add, remove, and perhaps edit the students' records. If utilization, student performance, or test item analysis data is extracted and returned to the development agency for analysis, the manager needs to know how to extract it.

Computer Managed Instruction (CMI) Requirements. This discussion of what data is recorded and how it is used was delayed to this point to reinforce the importance of "user-friendliness" here also. The CMI should also generally be self-contained, with minimal intervention required by local management personnel. Unless there is a specific reason not to do so, allow the students to register themselves to enter the ICW and let their performance on diagnostic tests determine their instructional sequence. Don't require the manager to add the students to the system, or assign the lessons that they'll take. The ICW should make it easier for the manager to perform his job, not add additional tasks to his already busy schedule. If the student must rely on the manager to intervene, then training will be dependent upon when the manager can "get around to it" and unnecessarily delayed.

Types of CMI Data Needed. The next consideration is the type of student data that you want or need to accumulate. What type of student performance data is to be captured, merely test scores and registration data, or a "screen by screen" record of their progress? How often will the data be returned to the training developer(s) for analysis and evaluation? Must the student data be reported to another agency for some management purpose, such as an update to the personnel data systems or the Community College of the Air Force? Is there a requirement for safeguarding either privacy act data or the integrity of your ICW tests? Since these CMI functions can also impact the selection of the training system configuration, the distribution media, and the authoring system, the requirements should be concisely defined. Specific reporting requirements to outside agencies such as the personnel system often dictate some aspects of what and when to report.

Further, look at how many students are anticipated at each training site in a given time frame. Don't overlook the impact of personnel turnover. How long will the students' records be maintained on the system to allow them opportunities to review previously completed material? What test item and ICW validation or evaluation data is required?

While storing only test scores for each student will likely meet all requirements for student performance and completion, additional information is often required for the ICW developer. They'll be interested in each student's response to each test item for use in test item validity and reliability evaluations. They may want to know which path(s) through the ICW were taken for each student, along with their test scores, to evaluate the criteria used for their instructional prescriptions and their validity. They'll likely want the students to complete a subjective critique of the ICW, and to correlate it against their scores. The amount of time spent in training is valuable information to both the training developer and management at all levels. How often will any of this data be extracted? All these issues impact how the CMI data will be stored and the volume of storage necessary.

Limiting CMI Data. As a general rule, CMI data requirements should be limited to the minimum of "needed, meaningful data", in order to minimize the storage required and to provide alternative storage media and locations. If it isn't both needed and significant, then don't store it. Note however, that if you must err, then err on the side of storing "too much" data. Should you later find that you need some data that hasn't been stored, it cannot usually be "recreated" or obtained by other means. Plan carefully, yet concisely!

CMI Data Storage Locations. Note that centralized storage of CMI data on a single floppy or hard disk (as opposed to a floppy per student, for example) makes it much easier to manage the ICW and extract any needed CMI data. However, this is not an ideal solution if there are multiple training systems or multiple copies of the ICW at the site. If there are multiple training systems at the site with the CMI data and courseware loaded to their hard disks, then the student must use the same system to complete the entire course. If there are multiple systems at the site using multiple copies of ICW stored on floppy diskettes, the student must always use the same copy of the ICW.

The student must always "report" to the same CMI data files, so in either of these cases it may

be easier to provide a floppy for each student to use for storing their records. If so, consider the cost of providing all these floppies and the potential for the student to lose theirs. You'll probably want to require that the students store their individual floppies in a centralized location to prevent losing them. It also makes them available at all times for preparing any management reports.

CMI Data Maintenance. Regardless of how or where the data is stored, there must be provisions to "deregister" students when they depart the location or their records are no longer needed for whatever reason. Is there a requirement to extract the student's records and forward them to another organization upon reassignment? Since the CMI data will be constantly growing, there must be some easy way to "clean out" other old CMI data. Similarly, there must be an easy process to extract any needed CMI data for provision to the training developers or others.

It may be beneficial to differentiate the data stored based on who requires the information, then store it in different files or locations based on intended use. This makes it easier to maintain only the essential data "on-line" while providing for easy extraction as needed. For example, we store each student's response to each test item or critique question in a "centralized" file for each test and critique, along with their student number for cross-referencing. We store their overall test scores for each test and/or objective in a single file for each student, along with other background information such as elapsed time in training. Every six months we extract the CMI data from each course at each site (using a "staggered" schedule) for evaluation using a single automated process.

This process copies to an empty diskette each student's data file, each test item analysis file, and the critique item analysis file. Then, the program deletes the test item and critique item analysis files from the ICW's CMI data diskette. Each student's overall status in the course is retained by their unique data file, which remains. However, the detailed test item and critique item analysis data is removed to prevent "overcrowding" the space allocated to CMI data. The new diskette containing these files is returned to the training developers for consolidation with the CMI data from other sites and subsequent evaluation. Because the item analysis files are cross-referenced by student number, we can make any necessary correlations in evaluating either the ICW or its tests.

Conclusion. The ultimate success of exportable ICW will likely be determined by how well it was planned, considering its unique challenges, and how well that plan was executed. Failures cannot likely be attributed to any inherent shortcomings in the media or concept. Exportable ICW has no one on site to make up for its weaknesses, expound on its merits, or make excuses for its failures. It must "live or die" on its own - and it reflects directly on the people who planned it, developed it and sent it out! Plan accordingly!

KEYWORDS 1. Exportable training 2. Distance education 3. Interactive courseware (ICW) 4. Interactive videodisc (IVD) 5. Computer-based training (CBT) .

A ROLE FOR THE PERFORMANCE TECHNOLOGIST

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Total Quality Management (TQM) is a moving force throughout industry and government today. Many people think that TQM is a vital key in our struggle to maintain leadership in the industrial world. (Peters, 1987) If TQM is vital then it must be implemented properly. Implementation of TQM is most successful when it is fully understood and properly supported. It is within the implementation part of TQM that the performance technologist can play an important role in assisting in the success of any TQM effort. This paper will suggest how the performance technologist can be instrumental in developing the training in the use of the TQM tools and also assist in identifying performance problems after TQM has been implemented. Before starting that discussion some definitions of TQM and some other background information will be provided.

Definitions. Quality has been defined as: Meeting the customers requirement the first time and everytime.(Western Executive Seminar Center, 1990) Also Quality has been defined as: Doing the right thing, right the first time, on time, all the time; always striving for improvement and always satisfying the customer(DoD TQM A Guide for Implementation, 1989). Quality is also defined by the Federal Government as: The extent to which a product or service meets customer requirements and is fit for use. (OBM Circular No. A-132, 1988)

Total Quality Management: A strategic, integrated management system for achieving customer satisfaction which involves all managers and employees and uses qualitative methods to continuously improve an organization's processes. (Federal Quality Institute,1990)

Another definition of TQM: A process that taps the creativity of all employees who are responsible for quality products and services, from top management to line employee, to achieve the ultimate goal, customer satisfaction.

TQM is both a philosophy and a group of guidelines and principles that are the basis for a continuously improving organization. It is the application of quantative methods and human resources that result in the improvement of products and services provided for a customer and the extent to which customers needs are met.

What the Leading Quality Experts Say About TQM Training. Dr. W. Edward Deming is perhaps most widely known for his work with the Japanese after World War II. He is a statistician and he began teaching statistical quality control in Japan in the 1940's. He is acknowledged as an important contributor to the Japanese ascendency in quality management. Dr. Deming states that companies should also establish constancy of purpose by means of innovation, research and education, continuous improvement of products and services and maintenance of equipment etc. (Walton, 1986). He is also noted for his fourteen points for management. Points six and thirteen are "institute training" and "institute a vigorous program of education and retraining." (Walton, 1986).

Dr. Joseph M. Juran has most likely contributed more to the fields of quality control and management as all other contributors combined. He taught the Japanese the principles of quality management in the 1950's. One of the main points in his philosophy is the need for quality training to stay competitive. According to Juran "....many Japanese companies have trained 100 % of their employees in the quality disciplines. Few U.S. companies provide quality training for more than five percent of their employees." (Quality Leadership, 1989).

Phillip B. Crosby, author of *Quality is Free* and *Quality Without Tears* developed the Zero Defects program and founded the Crosby Quality College. The essence of Crosby's quality improvement process is embodied in what he calls the Absolutes of Quality Management and the Basic Elements of Improvement. The Absolutes address the question of what quality is and what standards and systems are needed for the achievement of quality. One of his Basic Elements of Improvement is Quality training materials and instruction must be excellent.

The Tools Used for Continuous Improvement. An important part of TQM is identifying and correcting problems. There are some management tools that are used in the TQM process to identify and

correct problems and make continuous improvements. The tools used for continuous improvement can be divided into two categories as follows (Brassard, 1985):

Problem identification;
- Flow Charts
- Check Sheets
- Brainstorming
- Nominal Group Techniques

Problem Analysis
- Histograms
- Scatter Diagrams
- Control Charts
- Process Capability
- Force Field Analysis

Some tools can be included in either category. Those are:

- Pareto Charts
- Cause & Effect Charts
- Run Charts
- Stratification

There are several process/performance improvement models used for TQM. They all use the tools identified above in their process/performance improvement procedure. They also all follow the Plan-Do-Check-Act concept. The American Productivity & Quality Center's IMPACT model consist of six steps as follows:

- Planning
- Assessment
- Direction Setting
- Measures Development
- Service (RE) Design & Implementation
- Results, Review & Recycle

Other models consist of seven steps that are similar in many ways to the IMPACT process. What they have in common is in the planning step. This step almost always includes the requirement for training. The training required is to make all employees aware of the needs for and the benefits of TQM, and train them in the use of the tools and techniques to support continuous improvement. The scope and

intensity of training will depend on such factors as organizational level, nature of work, and specific processes under review for improvement. The training should be tailored to support the visions and goals set by top management

Performance Technologist's Role. There is a great tendency on the part of most people when hearing of TQM to think of it as just another program. Or they think of it as managements latest idea on how to get more output from an already over worked workforce. These false ideas are indeed difficult to overcome. There are other more difficult tasks associated with implementing TQM than correcting false ideas. One of the most difficult parts in adopting TQM is to get individuals to understand that TQM is a change in beliefs and subsequently a change in behavior. Getting individuals to understand that TQM is a change in beliefs is indeed a problem. Another aspect of that problem is to get individuals to ***change*** their beliefs. Causing these changes in beliefs and behavior (or performance) in individuals is how the instructional technologist and the performance technologist disciplines can be effectively used in all phases of a TQM effort. All people can change regardless of age and circumstance (Tough, 1982). When individuals in the organization fail to change their beliefs about Quality the TQM efforts will fail. This is the situation in many cases in organizations starting TQM where management dictates a change in behavior for the individuals and expect TQM to then just happen. What is needed is for the performance technologist to call on their skills to develop and deliver a training program that can assure the proper program outcomes. These skills include ensuring that the determining of instructional goals are shared with the learner, the atmosphere is conducive for learning, the learner is made comfortable, the learners experience is valued and the performance technologist takes on the role of a facilitator (Knowles, 1986) (Rose, 1985). These things can ensure the needed training support is in place to implement TQM.

Training and education are major parts of any TQM effort. This training is for understanding the TQM process and the training that results from the changes caused by TQM. The training referred to here is that training required to understand and implement TQM. Without proper training any effort to implement TQM is destined to failure. Not enough emphasis can be placed on the need to train all personnel because all personnel have to be involved in any TQM effort. Not only do the leading experts emphasize the need for continual training but so do others who have implemented TQM, such

as the USAF Air Logistic Center in Sacramento. There they have set up permanent TQM courses for all employees. Others include the GM assembly plant in Lakewood , Georgia, IBM, Federal Express and Disney(Peters, 1987). The Federal Government has set up the Federal Quality Institute to act as the clearing house for Federal Agencies who need vendors that have been certified to provide TQM training. OPM has two week TQM seminars at their Federal Executive Seminar Centers for senior Federal Executives. A word of caution is needed because mistakes can be made in TQM training. Care must be taken by the performance technologist to avoid these mistakes. Some of the common mistakes made in TQM training are

> Conducting mass training for everyone before support systems such as steering, process teams etc. for TQM have been set up.
>
> Overemphasizing the technical tools such as Flow Charts, Histograms at the expense of leadership and management issues.
>
> Oversimplifying and underestimating the difficulty in getting individuals to change their attitudes about Quality and TQM.

The undertaking of the TQM process can be thought of as a three phase effort. The first phase is the awareness and orientation to TQM models. Dr. Deming's model advocates the extensive use Statistical Quality Control techniques. This includes use of such tools as Pareto Analysis, Ishikawa Fishbone Diagrams, Histograms, Control Charts and Scatter Plots. Juran's approach is a model centered around three major quality processes: Quality Control and the Quality Sequence, Quality Improvement and the Breakthrough Sequence, and Quality Planning and the Annual Quality Program. The Crosby approach is in what he calls the Absolutes of Quality Management and the Basics Elements of Improvement.

The second phase is the introduction to the tools used in TQM. These tools are as provided above. All advocates of TQM rely totally on the use of some sorts of tools to collect data. Naturally some tools fit more appropriately with certain models.

The third phase is the implementation of TQM. Before this phase begins a decision should be made on which model or parts of models will be used by the organization.

The roles that could be played by the performance technologist will be addressed for each phase. Before doing that a brief description of learning outcomes as generally accepted by many performance technologists is needed. The five kinds of learning outcomes (Gagne', 1984,1985, and Gagne' & Briggs, 1979) will be related to the three phases of the TQM process. These outcomes are: intellectual skills, verbal information, cognitive strategies, motor skills and attitudes. The matching of learning outcomes to instructional strategies and task performance requirements are some of the processes that the performance technologists normally use in doing their work as well as providing instruction.

The first phase of the program is for the senior management and/or key personnel. Deming believes that it is only for senior management. Others believe it is for the explorers. Hopefully they are the same persons. The performance technologist's role at this point would be to provide briefings to those persons on the various concepts of the Quality Experts. This of course would require research by the performance technologist. It might also require that the performance technologist receive some training in the subject area. Visiting some agencies where TQM has been implemented would also be helpful. The important point is that the performance technologist can use their skills and knowledges on how to present verbal information and concepts to decision makers. The learning outcomes would be as follows:

> Intellectual skills consisting of concrete concepts and defined concepts.
>
> Concrete concepts would be such instances as identifying Demings (14) fourteen points for management.
>
> Defined concepts in TQM for this stage would be the demonstration of the use of TQM in an organization.
>
> Verbal Information or as it is sometimes called " declarative knowledge" can be associated with the learning the definitions of such things as TQM, Executive order 12637 etc.
>
> Attitudes outcomes are very important at this phase since the learner must establish new beliefs regarding quality.

These learning outcomes of course would be related to suitable instructional strategies.

The second phase is the introduction to the tools. There should be a broader base of persons involved with this phase than those involved in the first phase. Those included in the second phase are the first line supervisor, second line supervisor or manager, team leaders and those trained during phase one as they feel necessary. At this point the performance technologist might want to bring in outside support for those areas that they do not feel comfortable in presenting. This area involves using some statistical models as well as the use of group processes. If done by some outside agency then the performance technologist's role becomes one of determining whether the presenter can perform the required tasks. The learning outcomes are as follows:

> Intellectual skills which would involve the learning of the concrete concepts of the tools used for problem identification and analysis.
>
> Verbal Information as indicated above.
>
> Motor Skills outcomes as associated with the use of the various methods of collecting and munipulating data.

As always these learning outcomes must be tied to the appropriate instructional strategies. In this area there is the possibility that the presenter of the material could be an outside agency and that requires the performance technologist to define and monitor those activities.

The third phase is the implementation phase. At the outset of this phase management should have determined which model will be used to implement TQM and made a statement of management philosophy. A major role for the training technologist is to determine the training requirements to cause the cultural changes and the required paradigm shift and to help people through the land of DABDA (Denial-Anger-Bargaining-Depression-Acceptance). The learning outcomes for this training are as follows:

> Intellectual Skills consisting of Defined and Concrete Concepts and Rules and Higher Order Rules.

Cognitive Strategies

Verbal Information

Motor Skills

Attitudes.

The performance technologist must again develop the appropriate instructional strategy for the particular learning outcome. A decision must be made at this time how to provide the continuous training and education needed to support TQM.

Companies that are successful in implementing TQM state that many years are required to fully implement TQM. After more than thirty years it is said by the Japanese that they are just now beginning to fully implement TQM. If this is true then the plan for training must take this factor into account. Long term continuous training is needed. The significant point here is that there is a very important role that the performance technologist must play in the implementation of TQM. TRAINING!! As stated earlier by the experts, training is a very vital part of the TQM process. Who can better research, plan, and implement a training program for TQM than the performance technologist? No one!

Another area where the skills of the performance technologist are needed is in the assessment of performance of either the individual or the organization. After an organization decides to implement TQM one of the activities carried out by a team is a process analyzation. This includes looking at a process to determine who adds value to the process. This effort could be done using a Flow Chart or a Fish Bone Diagram. It is important during this assessment that discrepancies between required performance and actual performance of individuals be assessed and not become a complicating factor in determining the direction for TQM corrective actions. This could easily happen if the team doing the assessment does not include members who possess the skills that a performance technologists have.

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EVALUATING THE GENERAL FEASIBILITY OF INTERACTIVE COURSEWARE AS A TRAINING MEDIUM

Jeri Carter, PhD, and Robert D. Perkins

There are a number of difficult decisions that must be made to establish and manage efficiently and cost effectively an Interactive Courseware (ICW) development project. These decisions involve choosing an ICW system (including the hardware configuration and the authoring software) and developing a staffing plan to ensure that the work is completed on schedule within the project budget. Before any of these decisions can be addressed, however, the primary decision must be made: Is ICW a feasible training alternative given the anticipated training situation? The purpose of this paper is to provide information to training managers about a structured methodology for making the initial feasibility decision. The general feasibility of ICW normally is evaluated by examining a number of content, student, and organizational factors. Subsequent to a detailed discussion of these factors and the way in which they impact the feasibility decision, a simple, user-friendly decision aid is presented to assist training managers in the decision-making processes related to ICW feasibility. An informed decision at this stage expedites courseware development and, therefore, the Instructional System Development process.

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INTRODUCTION Presently, Interactive Courseware (ICW), a term used in the Department of Defense (DoD) to refer to materials needed for interactive training delivered via a computer (Joint Service Action Group, 1989), is a method of instruction highly sought in military training circles. Preliminary studies indicate that ICW can be a highly effective training medium. In suitable educational environments, it has been found to yield significant improvements in trainee achievement and transfer of training over conventional instructional methods. Some other attractive benefits of ICW include:

- Reduced training operation and maintenance costs
- Improved trainee motivation
- Automated management of training records
- Unlimited portability

It must be noted, however, that the key phrase in the above paragraph is, "suitable educational environments." In spite of ICW's relatively rapid escalation in popularity, due largely to concurrent advancements in capabilities and reductions in costs, it should not be perceived as a panacea for all inadequacies in existing training programs nor as the undisputed medium of choice for new training endeavors. Many decisions to incorporate ICW into training are made solely on the basis of a collective appetite for high-tech methods and machines or out of a competitive propensity to, technologically speaking, "keep up with the Jones'." Only an indepth, systematic, and multi-dimensional assessment of curricula and its goals can result in an accurate determination of the feasibility of incorporating ICW.

PURPOSE This paper provides information on a structured approach to determine the feasibility of interactive courseware as a training medium in a given training situation. Specifically, a step-by-step approach to the decision making process and a detailed description of the components of this process is delineated.

THE ICW DECISION The general feasibility of ICW is evaluated by examining a number of content, student, and organizational factors. These factors and the way in which they impact the ICW decision are discussed in the following paragraphs.

Content Factors. An information inventory administered to collect data in support of this paper showed that content was the primary consideration for evaluating the feasibility of incorporating ICW into the training environment. The following content factors contribute to the feasibility issue:

- Content characteristics
- Content stability
- ICW training time
- Course life cycle

<u>Content Characteristics</u>. The critical content-related element is the appropriateness of the match between the training objectives and ICW instructional features and other capabilities. Because ICW is a flexible medium with a variety of capabilities, it is a suitable medium for presenting many knowledge- and performance-based objectives. Specifically, ICW is especially appropriate for training objectives that are dependent upon or enhanced by graphic representation, photographs, or motion. ICW is also well used for instruction requiring group problem solving. However, it is contraindicated for certain levels and/or types of performance tasks. For example, ICW supplemented by motion sequences is an excellent choice for demonstrating interpersonal skills. The facial expressions and body language can be exaggerated for emphasis. Conversely, this medium is inappropriate for interpersonal skill task performance. Current technology does not allow computers to be programmed to evaluate this type of performance. Similarly, training a student to the competent and highly proficient level of task performance requires hands-on experience using operational equipment or training devices (three- dimensional simulation, mock-ups, part-task trainers, et cetera).

<u>Content Stability</u>. Content stability refers to the likelihood of the course material to change over time. Courseware maintenance refers to the process used to modify these materials be-

cause of changes in operational procedures, technical manuals or publications, or the equipment that is the focus of the training. Because content revisions require accessing and reprogramming lesson material, ICW is doubtful when courseware is expected to require two or more major content revisions per year. "Major" is defined by the percentage of course material requiring modification. Specifically, if more than 20% of the material becomes outdated, the revision is "major."

ICW Training Time. ICW training time refers to the number of ICW lessons in the course. Before making the feasibility determination, an estimate of training time is made. It is rarely advisable to present every lesson of a course through one medium. The content characteristics of different objectives will, almost certainly, require a media mix throughout any course. Prior to evaluating the content for "number of lessons," the nature of the content should be examined and an accurate estimate made of the number of ICW lessons in the course. Faulty decision making could result if the course length is assumed to be synonymous with projected number of ICW lessons.

Development and maintenance of ICW is expensive. Large portions of these costs are accrued during the course design stage of the Instructional System Development (ISD) process. These design costs are partially amortized across lessons; therefore, the cost per lesson is inversely related to the number of ICW lessons. Cost also is impacted by learning curve time during the initial stages of development. Generally, courseware developers must learn to use the hardware and the authoring software, and they must learn to understand and appropriately use ICW as a medium of instruction. As with design costs, the impact of learning curve costs decreases as the number of lessons increases.

Recent Air Force guidelines for selection of ICW as the medium of instruction for resident training state that the costs (applied to ICW equipment acquisition, lesson development, and courseware maintenance) must be offset within two years. If this level of savings cannot be achieved within the allotted time, ICW should not be considered. The following factors are used in calculating the amount of savings:

- Reduction in course length
- Reduction of operational equipment required and the associated equipment maintenance costs
- Reduction of required staffing to operate the training program (the savings realized by a requirement for fewer classroom instructors must be balanced by ICW development and maintenance requirements)

Course Life Cycle. As with number of ICW lessons, life cycle of the course also impacts cost inversely. Development costs are much lower per lesson when spread across a long life cycle. However, one complicating factor must also be considered. The longer the life cycle, the more likely it is that major revisions will be required. An accurate cost estimate must reflect maintenance costs as well as development costs.

Student Factors. Student factors also impact feasibility of incorporating ICW into a training situation. The projected number of students and the characteristics of those students should be examined. As in the previous discussions on training time and course life cycle, cost per lesson is inversely related to number of students. Regarding *student characteristics*, it is difficult to examine the characteristics of future students. Therefore, it is necessary to review records of previous students, given the potential for the same kind of students to matriculate in the future. The following is a partial list of student characteristics that support use of ICW:

- Visually-oriented learning style
- Adequate reading skills
- Low motivation

Given use of the full range of ICW capabilities, this type of instruction is quite helpful to students who are visually-oriented. Static and/or animated graphics can be incorporated to depict or illustrate abstract concepts; IVD capabilities can be used to demonstrate procedures. Even highly visual lessons probably will use some text to identify key points. Therefore, students need to possess "adequate" reading skills.

A high level of interactivity should be designed into lessons to enhance the learning experience

of poorly motivated students. Other techniques are also helpful in structuring the learning of students lacking in motivation. Specifically, lessons with frequent and numerous embedded questions and explicit feedback may increase motivation of these students. Embedded questions for these types of students should be designed for graduated difficulty so that a feeling of success is achieved.

Organizational Factors. Another set of factors that impacts the feasibility of ICW is the nature of the organization into which the training project fits. The following organizational factors are considered in determining feasibility:

- Current training equipment configuration
- Amount of organizational support
- Time schedule for development

Current Training Equipment Configuration. The current training equipment configuration is examined to assist in determining feasibility. Environments lacking the acquisition budget for hands-on equipment or training devices for task related skill development training could fill the gap by using ICW with demonstration and performance simulation capabilities.

Amount of Organizational Support. Several kinds of organization support are needed to facilitate the decision to incorporate ICW. The existence of this support should be examined prior to making the ICW decision. These support factors include:

- Staff availability and experience with ICW
- Instructor attitude towards ICW
- Management support for ICW

In evaluating staff resources, examine commitments planned for the time frame of ICW development. Staff availability must be examined in conjunction with other commitments and the likelihood of dedicating key staff members to the ICW project. Although staff experience with ICW is not prerequisite for implementation of ICW, experienced staff will certainly provide more courseware faster and cheaper. Frequently, instructors are initially resistant to ICW. Negative attitudes can hamper development and implementation. Lack of management support can hamper efforts in the same way. These factors need to be examined so that a judgement can be made about the relative amount of effort required to fully implement ICW into the training environment.

Time Schedule for Development. In some cases, there is limited time available for development before students are scheduled for training. All factors evaluated previously may lend strong support for ICW, but, if inadequate time is scheduled for development, it will not be a feasible choice. In evaluating this factor, remember that inexperienced personnel require more development time than experienced personnel. In addition, instructor resistance to and inadequate management support for ICW also may affect the organization's ability to meet schedules.

Decision Factor Summary. Table 1 on the following page summarizes these ICW feasibility factors and their impact on the ICW decision.

ICW Feasibility Decision Aid. Decision Aid 1 has been developed to assist in evaluating feasibility. This Decision Aid (presented after Table 1) lists the following:

- Each factor impacting the ICW decision
- A yes/no feasibility question
- Space for recording your answer

Three factors on this decision aid are especially critical because they directly or indirectly influence ICW costs. These factors include content stability, training time, and course life cycle. "No" responses to these questions provide strong evidence that ICW should not be pursued. These three factors are identified on Decision Aid 1 by a single asterisk. Another factor (training equipment) is also critical. A "yes" response to this question strongly indicates a need for ICW. This factor is identified by a double asterisk on Decision Aid 1. When you obtain "no" responses to the cost-related factors and a "yes" response to the training equipment factor, continue with the decision-making process. Your initial cost estimates may be in error. Probably, the cost of ICW can be justified when compared with the cost of sophisticated training devices or operational equipment. When you obtain "no" responses to all four of these factors, you have little justifica-

Factor Type	Factor	Data Examined	Impact on ICW Decision
Content	Content Characteristics	Training objectives	Consider ICW if training effectiveness is dependent on or enhanced by graphic, motion, or photographic presentation.
	Content Stability	Likelihood of major revisions	Consider ICW if major revisions are limited to one per year.
	Training Time	Projected number of ICW lessons	Consider ICW if the number of projected ICW lessons can off-set development and maintenance costs within two years.
	Course Life Cycle	Projected course life	Consider ICW if the course life expectancy is long enough to offset a reasonable portion of development/maintenance dollars.
Student	Learning Style	Former student records	Consider ICW if learning style is highly visual. (Resulting ICW should also be visually-oriented with heavy use of graphics and/or IVD capabilities.)
	Reading Ability	Former student records	Consider ICW only if reading ability supports projected reading level of anticipated lessons.
	Motivation Level	Former student records	Consider highly interactive ICW with frequent embedded questions/extensive feedback if low motivation is expected.
Organizational	Training Equipment	Availability for hands-on training	Consider ICW with simulation capabilities if hands-on equipment is unavailable.
	Staff Availability	Resources and commitments	Consider ICW if staff is available for dedicated assignment to ICW project.
	Staff Experience	Staff resumes	Consider ICW regardless of staff experience. Plan for learning curve time if staff is inexperienced.
	Attitude toward ICW	Staff meetings	Consider ICW if resistance is moderate or low. Plan for ICW awareness training if resistance is high.
	Support for ICW	Management meetings	Consider ICW if support is evident. Plan for development of position paper if support is low.
	Development Schedule	Management meetings	Given a short schedule, consider ICW if staff experience is extensive, instructor resistance is low, and management support is high.

Table 1. ICW Feasibility Summary

Factor Type	Factor	Feasibility Question	Yes	No
Content	Content Characteristics	Is ICW training effectiveness dependent on or enhanced by graphic, motion, or photographic presentation?		
	Content Stability *	Are major ICW revisions limited to one per year?		
	Training Time *	Can the number of projected ICW lessons offset development and maintenance costs within two years?		
	Course Life Cycle *	Is course life expectancy long enough to offset a reasonable portion of development or maintenance costs?		
Student	Learning Style	Is student learning style highly visual?		
	Reading Ability	Does reading ability support projected reading level of anticipated lessons?		
	Motivation Level	Is low motivation expected?		
Organizational	Training Equipment **	Is hands-on equipment unavailable for training?		
	Staff Availability	Is staff available for dedicated assignment to ICW?		
	Staff Experience	Is staff experienced in ICW development?		
	Attitude toward ICW	Is resistance to ICW moderate or low?		
	Support for ICW	Is support for ICW evident?		
	Development Schedule	Is the ICW development schedule flexible?		

Decision Aid 1. ICW Feasibility Determination

tion for ICW. Terminate the decision process, and pursue use of other media for training.

Of the remaining factors, pursue ICW if five or more "yes" responses are obtained. "Yes" responses to these feasibility questions indicate general feasibility as related to the associated question.

Exportability Decision Aid. If exportation of ICW to remote locations is planned, additional feasibility questions must be answered. Use Decision Aid 2 only when exportable ICW is planned. Decision Aid 2 is presented in three parts. Answer the questions on Part I first.

Exportability Questions	Yes	No
Is there existing hardware at the field unit that can support ICW training?		
Is the hardware sufficient to train the projected number of ICW students?		
Is the existing hardware available for ICW training?		

Decision Aid 2, Part I. Exportable ICW Feasibility

If you obtain three "yes" responses to the questions on Part I, skip Part II and proceed directly to Part III. However, a "no" response to any one of the questions on Part I requires that Part II be completed.

Exportability Questions	Yes	No
Is budget available for hardware/software procurement?		
Is budget available for operating ICW?		

Decision Aid 2, Part II. Exportable ICW Feasibility

A "no" response to either question on Part II indicates that exportable ICW cannot be supported by the field unit budget and should not be attempted until funds are allocated. "Yes" responses to Part II indicate that exportable ICW is feasible; proceed to Part III.

Exportability Questions	Yes	No
Is ICW the only appropriate media for presenting this content?		
Is the number of projected lessons large enough to justify ICW use?		
Is the number of projected students large enough to justify ICW use?		

Decision Aid 2, Part III Exportable ICW Feasibility

"Yes" responses to the questions on Part III indicate that exportable ICW is feasible. A "yes" response to the first question provides evidence that ICW is the only training alternative; this may override "no" responses to the second and third questions. A "no" response to the first question on this part and a "yes" responses to either the second or the third question provides support for exportable ICW.

CONCLUSION This paper offers a structured approach to a preliminary training requirements analysis designed to determine the general feasibility of using ICW. The methodology of this analysis is based on the examination of the following three factors:

- Content of the training program
- Characteristics of the prospective students
- Nature of the organization

Application of this approach, simplified by the use of decision aids, should assist in preventing the expenditure of excessive time and financial resources on ICW when an alternative instructional medium could fulfill the requirements more efficiently.

GUIDELINES FOR COMPUTER-BASED TRAINING (CBT) PLANNING, SELECTION AND IMPLEMENTATION

ABSTRACT

This project forms a part of a larger piece of research by Armstrong Laboratory, Human Resources Directorate concerning Computer-Based Training. For some time, Armstrong Laboratory has recognized the need for standardization of CBT planning, selection, and implementation procedures in the Air Force. This task was undertaken to provide research into the development of some tools which might be used to address the needs of organizations planning to implement CBT. The goal of the research is to improve overall training within the Air Force, and in particular in Air Force schools. As a part of the continuing research, the Laboratory has investigated ways of improving instructional quality by providing tools and assistance to the staff of Air Force training centers. This project makes a significant contribution to that effort.

The specific objective of this research was to determine those factors which are critical to Air Force organizations which are planning, selecting, or implementing CBT. By determining critical instructional setting variables, an organization may be able to select a CBT technology which best matches its requirements. The approach taken was to develop a questionnaire and decision aid which could be used by personnel and organizations inexperienced with CBT to categorize their training needs and evaluate CBT technologies in light of these needs. Factors considered are the various types of course objectives, student and staff needs, equipment compatibility, compatibility with other training organizations and courses, cost, and several other factors. A prototype instrument was developed which was aimed at performing many of the same functions as a CBT feasibility study. The instrument was tested on three typical Air Force organizations, and the results compared to the recommendations of four Air Force CBT consultants who were convened into an expert panel. The instrument was revised based on the results of try outs and the comments of the CBT expert panel. The paper-based instrument is now ready for operational testing with user commands, and eventual automation. The instrument provides Air Force users with a systematic, organized way of planning, selecting, and implementing CBT in their organization.

BIOGRAPHY

As a program manager for training technology William J. Walsh has been involved with CBT research and development over the past ten years. He has been involved in research activities such as determining training requirements, assessing training effectiveness and the proper application of CBT to Air Force training. Mr. Walsh has performed numerous cost-benefit analyses and training technology assessments for CBT, training simulators and embedded training.

CHARACTERIZATION OF AIR FORCE TRAINING AND COMPUTER-BASED TRAINING (CBT) SYSTEMS

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INTRODUCTION

The use of CBT technologies is widespread throughout the Air Force. When CBT has been properly planned for, and is implemented based on a sound plan, it can have a positive effect on both training effectiveness and efficiency. However, when CBT is not properly planned for, when an inappropriate CBT system is selected, or when a CBT implementation encounters problems, the results can be just the opposite. When improperly applied, CBT can potentially result in ineffective instruction resulting in substandard learning, or increased costs due to longer training times, courseware development problems, and logistics or maintenance problems. In addition, the inappropriate application of CBT can result in adverse impacts on a training organization's operating structure, functioning and resources. Given the current state of planning for and selecting CBT systems, these problems do not manifest themselves until a CBT system is being developed or implemented.

In determining the appropriate media application for their training environment, Air Force and other DoD users need to be able not only to select CBT from a group of other media alternatives, but also to select the most appropriate CBT system for their specific training needs. The selection of CBT should be made so that the users get the most powerful system for training, while the Air Force has the benefit of a cost effective solution. Since the Air Force currently has no standard procedures in effect to determine the use of CBT for instructional applications, the way in which CBT is selected and procured varies from command to command, and even within commands. Standardized procedures are needed to assist Air Force and DoD agencies in planning, selecting and procuring cost effective CBT systems that meet their current and projected training requirements.

Media selection models abound. Certainly, most media models provide detailed recommendations as to the most appropriate media to use in accomplishing a set of training requirements. However, as a group, media models do not normally assess an organization's ability to implement a particular medium. Certainly, none make recommendations as to how to implement the instructional technology in the specific instance of the organization. Still further, little is available to help assess an organization's ability to make use of CBT technology. What this report summarizes is the results of a study undertaken by Armstrong Laboratory to develop a means of advising inexperienced Air Force users on whether a specific CBT technology is appropriate for the organization's training needs, and to provide guidelines which would serve to *hold the user's hand* through

the CBT planning, selection and implementation process.

Originally, the research task focused on determining the information required by an organization for proper CBT planning, selection and implementation. By identifying this information, it was hoped that some linkage could be established with the most appropriate CBT technology, thereby streamlining the CBT selection process. It soon became obvious that the information requirements were integrally linked with the decisions which had to be made by training planners and managers when they considered the introduction of CBT into their organizations. At that point the focus shifted to the CBT decision process, including the information required to make it work. The results of that investigation are reported here. Ultimately, the goal of Armstrong Laboratory was to develop guidelines to aid managers and organizations inexperienced in planning for CBT. Put another way, the primary objective of the program was to develop a predictive instrument which would allow Air Force organizations to match their training requirements and instructional setting environment with the applicable CBT system(s) which best suits them, and to assess the impact of such technology on the organization.

From the reactions of several Air Force organizations which have been contacted, CBT planning, selection and implementation assistance is long overdue. Currently, organizations have few directives or guidance for implementing CBT. The Instructional Systems Development model may work well in other areas, but when it comes to implementing CBT the model provides little specific guidance to Air Force users. Furthermore, within the Air Force there seems to be no model to follow in planning or selecting a CBT system. Many Air Force organizations must either obtain the services of expert CBT consultants to help them in the CBT planning process, or rely on whatever in-house expertise they may have available to do the task for them. In both cases, there might be different results (given the same data), depending on who the consultant(s) or in-house experts are. Research has indicated that a lack of clear guidance for CBT planning, selection and implementation can sometime result in hesitancy on the part of the organization to implement a CBT technology. Because of an organization's uncertainty as to what and how much of their curriculum can benefit from CBT, there may be a tendency to maintain the status quo. Even worse, some organizations may forge ahead blindly into the realm of CBT without the necessary knowledge of how CBT may impact the training requirements or the organization for better or for worse.

This paper describes how Armstrong Laboratory has set about solving some of the CBT planning, selection and implementation problems facing the Air Force today. It will describe briefly the methodology employed in developing a set of guidelines to assist the Air Force users through these difficult problems. It will also include some specific features of the CBT planning, selection and implementation guidelines which resulted from the study. The instrument itself is currently available for further research and validation through Armstrong Laboratory, Human Resources Directorate (AL/HRTC). Although the instrument has been tested in the field, it cannot be considered final in any sense of the word, since there still remain areas of research to be explored in CBT planning, selection and implementation.

METHODOLOGY

The methodology used for this study consisted of the following major steps, each of which will be described in detail in this report:

- Determine the problem
- Develop the Instructional Setting Inventory (ISI)
- Develop the CBT Inventory
- Test the inventories
- Determine CBT decisions
- Validate the instrument with Air Force users
- Validate the instrument with CBT experts

Determine the Problem

Initially, the researchers focused on potential solutions, i.e., an updated ISD model, various commercial CBT planning and selection programs, etc. The ISD guidance which is currently available to Air Force users is general in nature, and there seemed to be no good reason to provide parallel guidance. Several commercial products available provide more detailed advice, but none of them is tailored to the Air Force resident training environment. The researchers eventually concluded that generic guidelines would only be of minimal help to the users. While such documents are useful references for Air Force users, only the more experienced among them can solve their CBT needs using such products alone. Certainly, many of these documents go a long way towards expanding the knowledge base of the users regarding CBT technologies. But none of them are specifically aimed at answering the difficult questions which face an organization which is contemplating implementing CBT. Nor are these products designed with the inexperienced user in mind. Many of them presuppose that the user knows quite a bit about CBT technology and its impact on the learning environment and the organization as a whole.

The researchers focused on the question: *What is the problem in Air Force CBT planning, selection and implementation?* They relied on three sources of data to answer this question:

1. The opinions of Air Force personnel who had recently implemented a CBT program at their command. This helped determine what was done right and what was done wrong.

2. Intensive interviews with Air Force personnel inexperienced in CBT planning, selection and implementation. This helped determine what the inexperienced personnel might be expected to know or not know, and what that person might be able to do.

3. The researchers' own experience in planning, selecting and implementing CBT for Air Force users. This formed the basis for querying the users, and a knowledge base of CBT expertise.

In the opinion of the researchers, what was really needed was to mirror the advice that a skilled consultant would provide to an organization which had little or no CBT technology experience.

Develop Instructional Setting Inventory

Looking at what an expert CBT consultant does in terms of an *Input-Process-Output* model, the research task is

twofold: first to determine what data or *Input* the consultant uses in making his recommendations regarding CBT, and second, to model the *Process* which the consultant goes through in making his recommendation. The desired *Output* was known, or at least the form that the users wanted, namely a *Yes/No* recommendation regarding CBT and some advice on how to handle the various details if CBT were selected. Looking at the problem in terms of the *Input-Process-Output* model means that any system devised to help the typical Air Force user has to gather and analyze the same kind of information that an expert CBT consultant would use in making his recommendations. The logical first step seemed to be to determine what type of information an expert CBT consultant needed to know about an organization and about CBT systems in general, in order to make his recommendations.

Several personnel on the staff for this project had performed such *consulting* work with Air Force user organizations. These personnel were quite familiar with the types of questions which the managers of a training organization usually ask. They were also familiar with many of the constraints within which Air Force organizations had to work. They also had a clear idea of what kind of information a training organization would have available or be able to get. From this starting point the researchers began by cataloging the information which they, as *CBT consultants*, would need in order to advise an organization regarding the implementation of CBT. The first objective in determining the information requirements for CBT planning, selection and implementation was to develop an Instructional Setting Inventory (ISI). The purpose of the ISI was to characterize Air Force resident training school environments in as much detail as practical and usable. The intent was that by using the ISI one could encompass the entire range of training center and school management, administration, training delivery, courseware development, logistics support, operations, and maintenance functions performed. The hope was that by being able to fully describe the resident training school environment they would also be able to identify most of the critical decisions, key factors, variables, interactions, and information requirements needed to fully characterize and measure the instructional setting for the introduction of CBT. Prior experience had shown that each variable in an instructional setting could be critical to successful CBT implementation, therefore, the more exhaustive our list, the better it would be.

As a measurement instrument, the ISI had to capture data on an organization as it currently operates and does business. Since the research staff included personnel who had direct experience in Air Force training center operations, it was relatively easy to identify what needed to be asked about current operations. Moreover, the ISI has to be able to characterize the organization's ability to adapt itself to CBT. This might require changes in administration, management, logistics support, or other organizational factors besides training delivery and day-to-day operations. So in addition to asking questions about what is currently taking place, the ISI has to be able to capture data which could be used for making predictions about the organization. This requirement necessitated that certain questions be inserted into the ISI which gathered information on the organization's desired goals and future intent. This was, perhaps, the hardest part in constructing the ISI. Some of the staff felt that the ISI had to approach an organization's future intentions

without biasing the respondents in favor of CBT; therefore, it shouldn't ask them anything about CBT directly. Ultimately, the approach taken was very straightforward. The ISI asked the participants about the expectations they had for improving their organization by introducing CBT. It was felt that this minimized introducing any bias in favor of CBT, yet it still got the required information about the organization's future intentions.

Develop CBT Inventory

Just as the ISI was developed to characterize the Air Force training center or school environment, a CBT Inventory was developed to allow Air Force organizations to categorize the functions, allocations, capabilities and performance of currently available CBT systems. Thus, in combination, the ISI and the CBT Inventory would allow an Air Force organization to determine their organizational climate for CBT and to match their requirements with existing CBT system capabilities. The specifics of how to do that, namely what decisions regarding the organization and CBT had to be made, were yet to be developed.

There were differing opinions among the research staff as to how to *categorize* CBT systems. Some thought it might be necessary to make an exhaustive comparison across vendor CBT systems. This database of vendor capabilities might parallel the kind of information that CBT expert consultants would have available to them in order to make their recommendations. However, others argued that it would not be advantageous for the CBT Inventory to be a catalog of current CBT systems. If the CBT Inventory were to take that form it would immediately *date* the instrument. If a single system were to change, the CBT Inventory's usefulness would be diminished. Rather, the problem was approached from another angle: *How could an organization's CBT requirements be described so that the organization could effectively evaluate various CBT technologies available to meet these requirements at any point in time, current or future?* The focus of the CBT Inventory was changed from the capabilities of CBT systems to defining the specific capabilities needed to meet the organization's training requirements. This also seemed to be much closer to what an expert CBT consultant would do in assessing an organization's requirements, i.e., determine the requirements and then use the requirements to evaluate available CBT systems. This would bring into play the necessity for the user organization to make its own judgments as to which path to take. The organization would be able to judge for itself which CBT system was the most advantageous for the organization. Cost and other factors would have to be taken into account by the user organization, but with some assistance as to how to weigh each factor in its decision.

Test Data Collection Instruments

Once the two inventories had been developed, they were tested with members of the target population at four separate organizations. The pilot test was performed to determine if the inventories were collecting the right data, to see if the required data was readily available at the participating organizations, and to ascertain that the questions could be answered by the participants without the assistance of someone outside the organization. Since the inventories asked some detailed questions about various components of the curriculum and the organization, it was determined that it might be necessary for some participating organizations to have several different

people provide the needed input to answer some sections of the inventories. In addition, the involvement of more than a single individual in the CBT planning and selection process was viewed as fostering an environment for successful implementation of CBT within the organization. This would allow many people to *buy into* the CBT decision, and it also afforded the opportunity for the more creative individual(s) in an organization to *emerge*. These personnel have proven to be invaluable contributors to any CBT effort. The pilot testing provided us some useful information on both the content and format of the questions. Some of our test participants who had some CBT experience even went so far as to provide suggestions regarding topics they thought should be included which had previously been omitted. At the end of pilot testing, the instruments were revised to account for any problems or difficulties which were identified.

Determine CBT Decisions

It soon became evident that the information required for proper CBT planning, selection and implementation was integrally linked to the decisions which had to be made. At the start of the project the distinct linkage between many of the decisions was less obvious. For example, although it seemed logical to separate the decisions regarding hardware and authoring systems from decisions regarding authoring in house or obtaining contract assistance, it was soon determined that these decisions were quite dependent upon each other. Normally authoring system decisions include factors regarding ease of use. These factors are linked to the ability of the organization's staff to author, which is linked to the need to get authoring training for the staff, which is, in turn, linked to staff turnover, etc. Each decision which had to be made seemed to have some kind of impact on several others. Once it was clear that there would be little possibility of separating the decision process cleanly into two parts, the idea of assessing the organization's setting or climate for CBT separate from the kind of CBT system which would be suitable for it was dismissed. This was a critical conclusion for the format of the eventual product. Instead of two separate instruments: one to assess the instructional setting, and another one to assess the capabilities of applicable CBT technologies, these instruments would have to be combined into a single instrument which would provide the required data. It also meant that the relationships among the various decisions would have to be determined, and these relationships integrated into a logical CBT planning and selection process which would allow the users of the instrument to reach the proper conclusions about CBT in a way that was *transparent* to the user.

The approach taken in determining the decisions which needed to be made by an organization consisted of two parts. First, a catalog was made of the decisions which had to be made in planning for CBT, selecting an appropriate CBT system, and in implementing CBT in an organization. Included in this catalog were the *decisions* themselves, the decision points in the CBT planning, selection and implementation process, and the various options which should be considered at each of these points. Project researchers reviewed the procedures they had successfully used before in assisting various Air Force organizations in selecting CBT systems for their training requirements. Each researcher listed those decisions and decision points which they had encountered in the CBT planning process. The researchers also described in

detail the information needed to make their recommendations. This step resulted in many overlapping and complementary decisions being identified by the researchers. Also, much of the information which they determined to be useful, was in fact needed for more than one of the decisions. As a consequence, before anything further could be done to structure these decisions into some kind of logical progression, the researchers had to determine exactly what data was needed for which decision. Then they had to sort through the decisions which had been identified to determine the relationship(s) which existed among them. Of necessity, this second step involved the integration of the two inventories into a single data gathering instrument which could be used in conjunction with the various decisions which had to be made.

The instrument which was being developed began to take the form of an *Input Component* (composed of the Instructional Setting and CBT Inventories, now combined into a single Questionnaire), and a *Process Component* (consisting of 24 separate yet linked decisions through which the users would be lead). Figure 1 summarizes what had been done to that point.

The final step taken prior to testing the instrument on a user organization, was to organize the decisions into a logical order. There were two reasons for this. First, it would let the users know where they were at any time throughout the decision process. The often misapplied term, *user friendly*, was the watchword in developing the document. User acceptance of the instrument was critical, and it was felt that

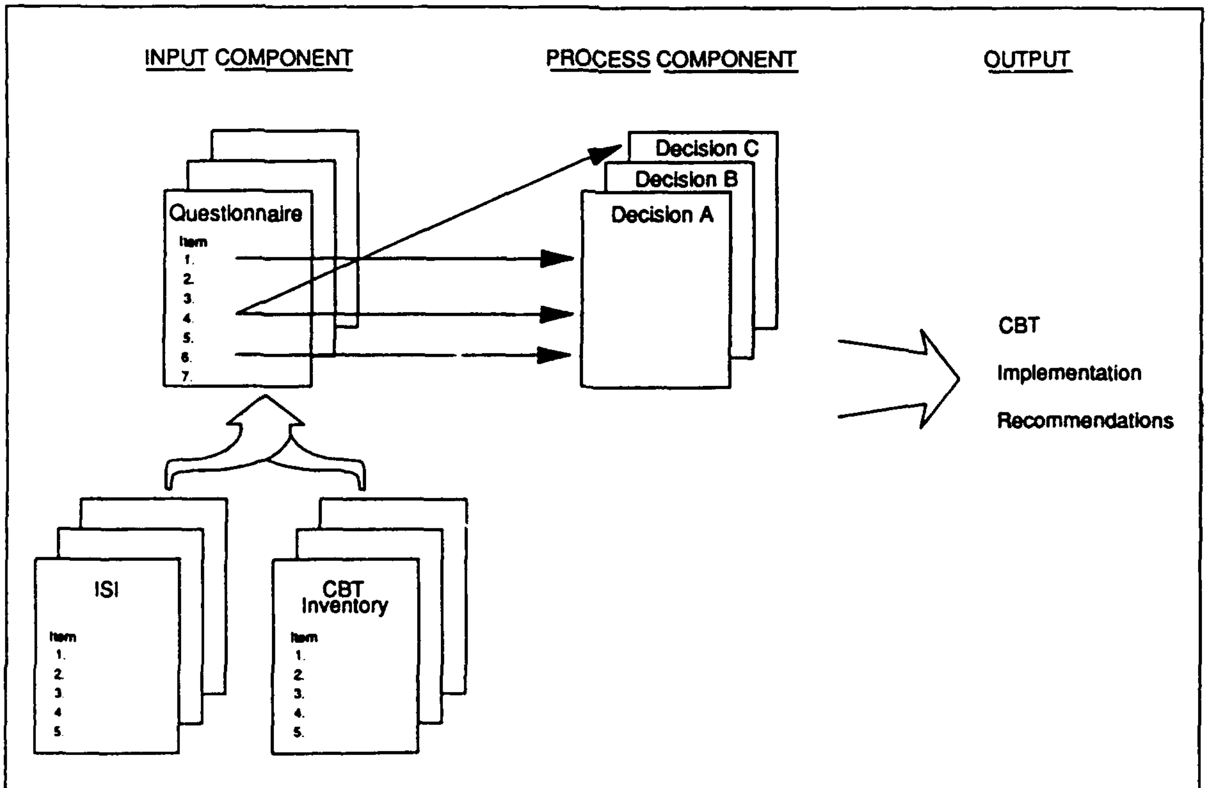

Figure 1. Relationship of the Inventories to the Decisions

the more *user friendly* the document was the better it would be accepted. If the research were to produce a document which would accurately predict an organization's requirements and match these with an appropriate CBT system, such an instrument still might fail unless it were employed by the Air Force user in CBT planning. Anything which would contribute to user acceptance of the instrument was evaluated and, if warranted, included. As a second reason, the structuring of the decisions could also provide another organizing principle for the items in the Questionnaire. (It should be pointed out that the primary basis for the organization of the questionnaire was the *source* of the data. For instance, questions about information which would most likely be found in the same documents, office, or area were grouped together in the questionnaire. This was thought to be the simplest way to structure the Questionnaire for ease of use.)

Another word about *user friendly.* This paper makes a point that the instrument which was developed for Armstrong Laboratory is *user friendly* in a way that none of the other documents which aid CBT users are. What is meant is: when the instrument asks questions, they should be questions the user is able to answer; when the instrument gives directions, the user should be able to follow them; whenever the instrument directs the user to do something, the user should be able to do it; when the instrument tells the user that he will be able to determine something, if he follows the procedures, then it should be obvious to the user what the results are, and when he has achieved them, etc. As an example, most CBT decision aids ask the user such questions as: Are alternate character fonts needed? In our opinion, this question should never be asked of the user. The user really wants and needs help in determining the answer to this question. The questions which should be asked are ones which determine what the user's requirements actually are. Such questions as whether there are various type styles used in existing materials which need to be duplicated in the CBT lessons, etc. The procedures which the user is asked to follow by a decision aid should tell him that alternate character fonts are or are not a factor to be considered in judging which authoring system to use.

What does the structure of the decision hierarchy look like? Figure 2 is the *roadmap* of decisions extracted directly from the instrument. As can be seen from the *roadmap*, the instrument is structured so that a user can quickly determine whether some CBT technology is applicable to the organization's training requirements. At that point in the process the user reaches a *Yes/No* decision. If the organization can make use of CBT, the rest of the instrument is used to determine how to best implement the technology. If the initial decision process does not recommend implementing CBT, the user still has the option of completing the rest of the decisions. If the user decides that CBT should be implemented even though it has not been recommended, he must still complete the rest of the sections of the instrument to determine the specifics of implementation. As he works his way through the various decision points, it will become clearer that he has made the wrong decision. Hopefully, the users will come to the realization that CBT is not always the most appropriate technology to address every training need.

The determination of cost was purposely left to last. Several of the participants in the test group commented that they appreciated this approach. While each organization's decision to implement CBT will ultimately be decided on whether

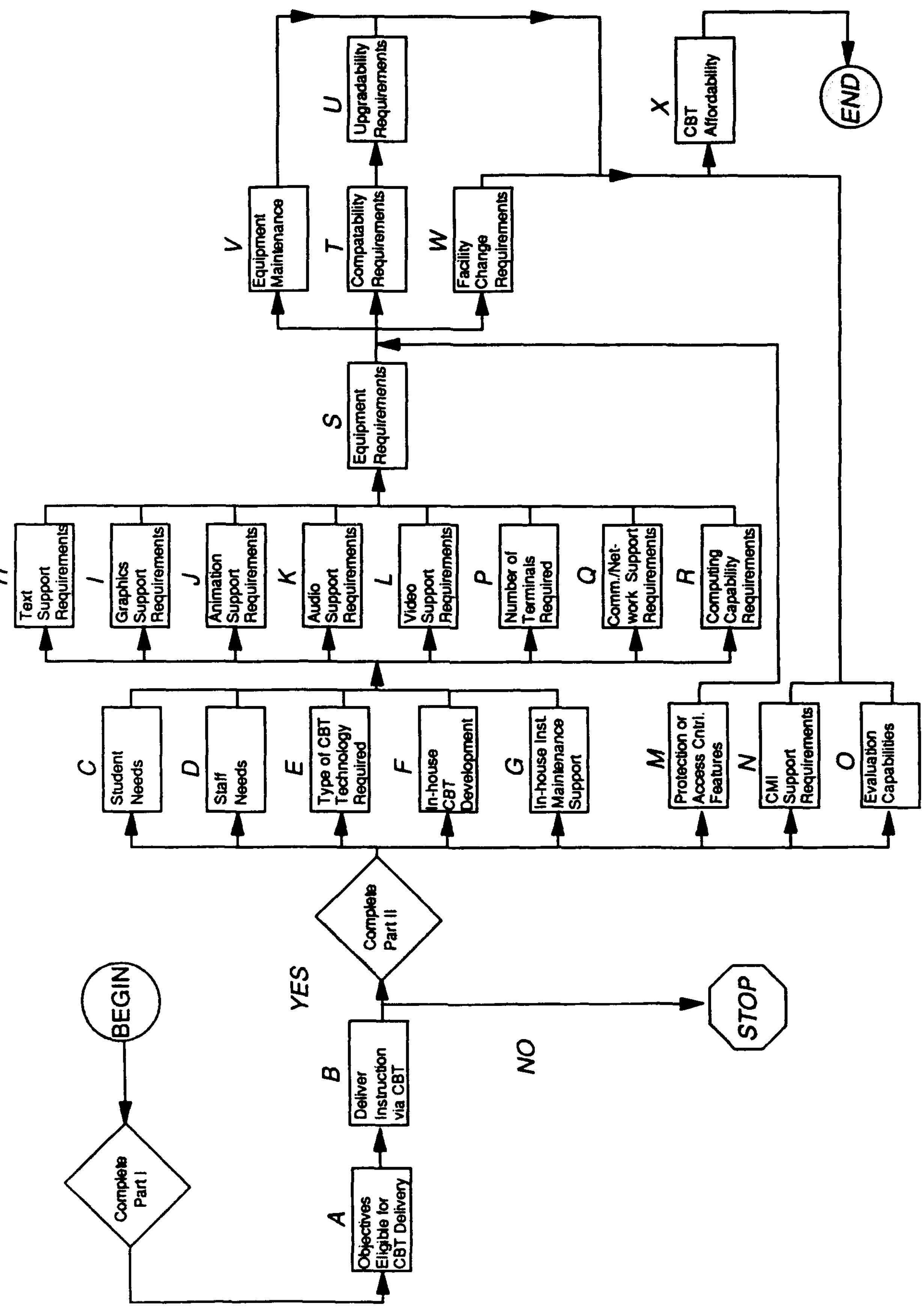

Figure 2. ROADMAP

the time, money and personnel required are available, it was still felt that each decision regarding the applicability of CBT should be based primarily on the training requirements. There is frequently enough time and effort devoted to determining whether an organization can afford to implement CBT.

Validate the Instrument with Users

In order to validate the instrument, Armstrong Laboratory scientists contacted various Air Force organizations which were thought to be in the process of planning or selecting CBT. They were able to identify three organizations which were about to begin the planning process at that time. These organizations represented diverse organizational types (two of them being formal schools, the other a training support organization), with different course requirements (one course involved pilot training, the other involved avionics maintenance, and the third logistics), and varying levels of CBT experience (two organizations were inexperienced, the other had a few personnel with CBT experience on staff). Each organization was contacted and asked to participate in the study. Each was enthusiastic about participating. They felt that any help in this area would be useful.

The validation process consisted of two steps. First, the organizations were visited by the Armstrong Laboratory program manager who provided them with copies of the instrument and briefly consulted with them on how to make use of it. The program manager remained on-site at the organization throughout a portion of the time that they were using the instrument. This was done to ensure that the organizations would devote sufficient time to working with the instrument, and to answer any questions which might arise regarding interpretation of what the instrument meant. The program manager was fully aware of what the instrument consisted of, but he did not participate in the development of the questionnaire or the various decisions which comprised the instrument. The feeling was that his presence at the organization would ensure cooperation, yet still allow the instrument to stand on its own.

The second step in the validation process was debriefing the organization after they used the instrument to determine the applicability of CBT technology. A staff member was sent to each organization after they had used the instrument. The researcher interviewed each participant in the program. The interviews concentrated on three things:

1. Did the instrument help the organization reach a decision regarding CBT?

2. Were the users satisfied or dissatisfied with how the instrument helped them achieve the organization's goals?

3. Was the instrument *user friendly*?

Once the interviews were completed, the information gathered from each organization was compared to determine if there were trends in their comments. There was unanimity among those participating that the instrument helped them through the CBT decision process. If they were inexperienced, they said that the document provided organization to the process and guided them through several decisions which they would never have thought of otherwise. If they had some experience, they said that the instrument was *something*

that they needed two years ago. Although there were several comments regarding desired changes to specific items on the questionnaire or formulas in the various decision sections, each participant felt that the instrument was just what they needed. Their specific comments regarding suggested changes to the document to make it more *user friendly* were also collected and analyzed. The changes recommended by the participants were evaluated with other data to determine which ones would be implemented prior to further testing of the instrument with other organizations.

Validate the Instrument with CBT Experts

Armstrong Laboratory was encouraged by the results of the pilot testing of the instrument. However, a second test of the instrument involving CBT experts yielded even more surprising results. The Laboratory has always had concerns regarding the validity of the instrument. Their concerns were that in spite of the fact that the instrument was successful in some individual cases, how could one predict that it would be just as successful in other applications? The argument was posited that the instrument was supposed to take the place of a feasibility study which would normally be conducted by an expert CBT consultant. Therefore, let the results obtained from the instrument be compared to the results of an expert when given the same information about the organization.

Armstrong Laboratory scientists agreed that the best way to assess the validity of the instrument was to compare its results to those of an expert. The only question which remained was: *Who were the experts?* The Laboratory contacted many Air Force organizations involved in CBT to get their opinion on who they felt were recognized experts in CBT technology. In particular, they sought experts in CBT planning, selection and implementation. Several experts were identified, and from that group four were selected to participate in the validation. The Laboratory convened the panel of expert CBT consultants in October 1990. The group of experts were highly qualified having a combined total of over 27 years of CBT experience. As a group they had been involved with all stages of CBT, in particular the planning, selection and acquisition of several large scale Air Force CBT systems involving hundreds of users. They had also been called upon from time-to-time to provide advice in planning for smaller, more specialized CBT systems. They were familiar with the state-of-the-art in CBT technology. Their experience extended to numerous different hardware and software configurations. The Laboratory felt confident that these CBT experts knew what they were talking about.

These four individuals met for four days to validate the instrument. The experts were only partially informed of the conditions under which they were being assembled. They were told that their services would be needed to validate a process of selecting CBT. When they arrived, they were briefed by the Laboratory Program Manager regarding the general goals of the program, however they were not given any information about the instrument which had been developed nor the results of the first pilot test. In fact, they were unaware that the instrument had been developed yet.

Having thus set the stage, the group was given its first task. The task consisted of asking them to provide expert consultant services to an organization which was considering CBT. One of the two pilot test sites was selected as the basis for

comparison. The data from that site was made available to the expert panel, but only if/when they asked for it. In withholding the information that had been gathered from the organization, the objective was to determine if the experts would also ask for the same or similar information. As the information was requested by various panel members, it was provided to the group. The experts were observed by personnel from Armstrong Laboratory and from the research staff to document whatever decisions, recommendations, and questions they might have. The experts were informed that they would have to debrief Laboratory scientists at the end of the second day. In their debriefing they were to provide whatever advice they felt the organization would need in planning, selecting and implementing CBT. They were also to provide a description of what they did and why they did it.

At the end of their first task, the expert panel provided their CBT recommendations for the selected organization. The recommendations of the expert panel and the conclusions arrived at by inexperienced personnel using the instrument were very similar. Both recommended CBT for a subset of the objectives; both recommended using a network configuration to gather CMI information; both recommended using CBT as a type of *part-task training*; and, both estimated the amount of time and personnel required to develop CBT in-house, etc.

During and after their briefing the expert panel was still not told of the results arrived at by inexperienced personnel using the instrument. All of their input was received, essentially without comment regarding its relevance to the validation of the instrument. The intention with regards to the expert panel's recommendations was to use these comments as a basis for comparison with the conclusions arrived at by the user organization using the instrument. But the results achieved were not to be the only basis for comparison. It was also considered important to look at the other two components involved in making a CBT decision, namely the information required, *the Input* and the method used to make each decision, *the Process*. As can be seen from Figure 3 the intention was not merely to match the recommendations of the panel with the conclusions of the instrument, *the Output*. That would still leave a *black box*, i.e., how do the processes compare, and how do the data needed by each process compare. As a consequence, the research team observed the procedures used by the experts in arriving at their recommendation, asked them to explain why they did various things, and noted the information which they thought necessary to make their decisions.

Once they had completed their debriefing, the expert panel was informed of their second task, i.e., to critique the instrument. They were informed of the purpose of the instrument, how it was created, and briefly, how it was organized. The panel members were directed to take the document away with them to review on their own. Working alone they were to review it and critique its contents, format and approach. They were asked to be as critical as they could be, but to do so in a positive way, i.e., whenever there was something which was not to their liking, they were asked to suggest an improvement. Each expert was asked to prepare another briefing of his own critique of the instrument. Without being directed to do so, each person focused on a slightly different aspect of the instrument during his critique. The experts provided the specific, detailed criticism expected of them. On the whole,

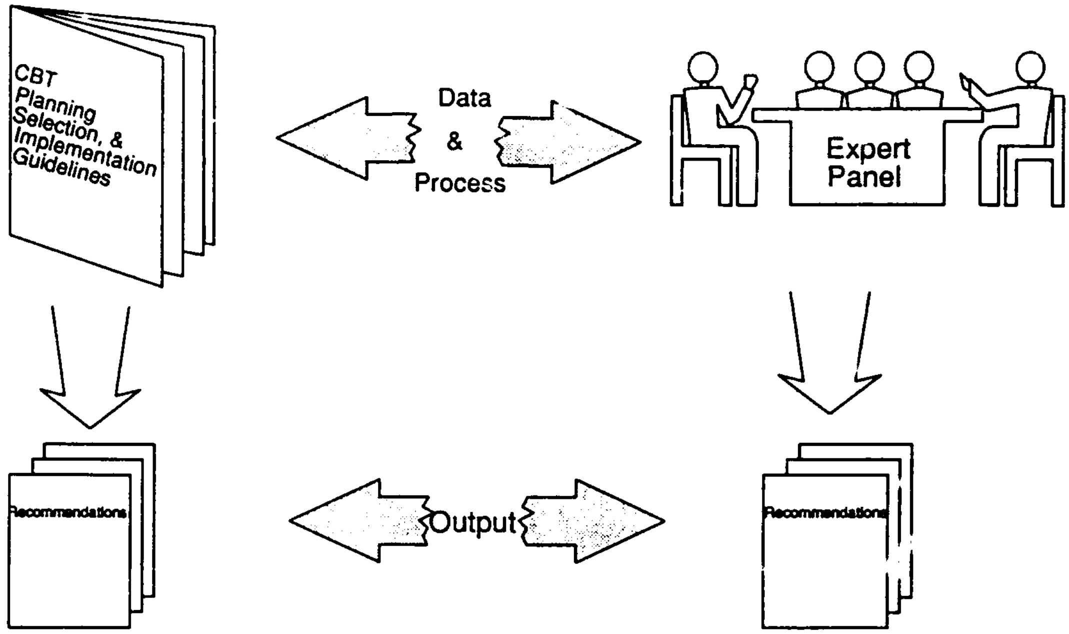

Figure 3. Basis for Comparison between an Expert Panel and the Instrument

their acceptance of the instrument was remarkably universal. As a matter of fact, each participant requested that they be provided a copy of the finished document to help them in future CBT planning. One of the panel members suggested that a follow-up test of the instrument be performed with an organization which he knew was contemplating CBT, but was inexperienced in CBT planning, selection and implementation.

CONCLUSIONS

What the Instrument does and does not do!

What do the advice or recommendations provided by the instrument look like? The last thing which is needed or wanted by user organizations is a single solution to multiple problems. In other words, a standardized CBT system for the entire Air Force (or even some major commands with diverse needs) would do little to provide an appropriate training solution to the myriad of environments which are to be found in Air Force formal schools. Also, the managers of training programs do not need a tool which provides them with only a single solution to match their training needs. Managers must be able to make decisions given various alternative approaches to their training requirements. They need an instrument which gives them more than one way to look at the training requirements and potential solutions. As with most good managers, training managers need to be able to play *What if?* with the solutions to their problems. The instrument which has been developed allows them to do just that.

Since the advice of an expert consultant retained for a feasibility study of this type would normally result in the

production of several documents needed by the organization to acquire the recommended CBT system, the instrument attempts to emulate that same approach. The Output Component of the instrument either provides or causes the organization to gather the necessary information required to acquire the CBT system. An expert would probably leave an organization with something approximating the information listed below, therefore, the instrument also provides the same data:

1. A description of which objectives can and cannot be converted to CBT. The instrument makes this determination right up front. It is the basis for all further CBT planning. The instrument will indicate to an organization how much of its curriculum can be converted to CBT. It leaves the decision as to how much will be converted up to the organization's managers. They will have to determine what they can afford to do given the resources that they have available to them.

2. Recommendations as to which CBT technology (e.g., CAI, IVD, DVI, simulation, etc.) would suit the organization's needs. Such a recommendation would normally consist of two parts: a description of the applicable CBT technologies and which objectives the technology is suitable for; and advice concerning the cost effectiveness of the implementation of the CBT technologies. (The instrument provides specific recommendations as to what type of CBT technology can be used. The instrument also leads the user organization through its curriculum to determine how sophisticated the CBT system and lessons will need to be.)

3. Some rough order of magnitude estimate of the cost of implementing the CBT technology, both in terms of dollars required, personnel needed and facilities change requirements. (As was mentioned before, costs are not computed until the very end. When costs are computed, the organization will be able to determine where they stand. Namely, if they will need to POM for the required resources; if the amount needed is beyond all hope of ever achieving; or, if CBT technology might be feasible using in-house resources, etc.)

4. The data needed for a specification which the organization could use to acquire the system. Normally, no expert would recommend a single specific system as the only way for an organization to go; therefore, the specification would be based on the organization's requirements and provide the organization the means of judging among several competing systems. (The instrument does not automatically produce a specification, but it does gather and organize almost all of the information required to construct such a specification.)

What does the instrument not do? This document was rapidly developed and serves as a prototype for CBT planning, selection and implementation decision making. The instrument has only been tested on a limited number of organizations, therefore it must still be considered preliminary until more definitive results are obtained. One problem associated with

testing this instrument is that the number of organizations considering implementing CBT at any one time is rather small. Once an organization contemplating CBT is identified, getting the organization to participate in the study will probably not be a problem (each organization contacted during this study readily accepted the opportunity). Given the small number of organizations contemplating CBT during a specific period, obtaining sufficient data from continued testing of the instrument might pose a problem. Depending on what criteria were established for acceptance of the results of such a test, Armstrong Laboratory may be able to continue testing with internal Air Force resources.

The modular structure of the instrument, and the direct linkage which has been established between the various questions in the questionnaire and the CBT decision points makes the instrument a prime candidate for automation. Various levels of automation can and should be applied to the instrument. By automating the instrument, its usefulness to the user increases significantly. As a paper-based tool, the instrument is limited to the single set of answers that the organization provides. By automating the system, the instrument allows the organization to try out several different configurations before settling with the one that suits their needs and they can afford. Several levels of automation are available to the Air Force:

1. **Simple automation.** This could be accomplished by programming the various decisions to take advantage of a database of information constructed by the questionnaire and objectives, and some kind of interactive spreadsheet to perform the cost and sizing functions.

2. **Sophisticated programming and branching**. This level could be achieved by more extensive programming to link various questions and change parameters within the program shell. The user would be branched to certain sections or around others depending on answers to previous questions.

3. **Artificial intelligence.** This would allow the user to interact with the program and be advised about new decisions he needs to make based on decisions which he has made previously.

Other CBT Decision Aids

Prior to developing the instrument, the research team investigated commercially available CBT decision aids which might perform comparable functions. Several systems were examined, and the literature reviewed. Although there are several systems available which perform media selection, and others which perform cost analysis of alternative media, none of the systems examined consider the complete range of variables utilized in the instrument to make a recommendation. It was not the goal of the researchers to conduct a comprehensive review of commercial automated CBT decision aids, but they did attempt to contact a number of vendors to determine what kind of systems were available. After reviewing several systems, the researchers determined that an inexperienced Air Force organization considering CBT would need assistance in several more areas than those provided by the commercial systems. The development of the instrument was aimed at plugging some of the gaps identified in these systems.

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ONE OF THE BIGGEST COMPUTER BASED
TRAINING SYSTEMS IN THE WORLD

Air Training Command is the Executive Agent for cryptologic linguist and analysis and reporting training and the Responsible Training Authority for certain general intelligence training for all four military services, as well as other government agencies. All Air Force intelligence training was consolidated at Goodfellow Air Force Base, San Angelo, Texas in 1985. Since collocating this training, the Goodfellow Technical Training Center (GTTC) has been in the forefront of employing state-of-the-art computer based training (CBT) technology. CBT at GTTC is being implemented through the acquisition of the SENTINEL training systems (SENTINEL ASPEN and SENTINEL BRIGHT). These systems are being integrated through a conceptual program called SENTINEL CONCHO. While several of the SENTINEL training systems are bigger than any other training system in the Department of Defense (DOD), combined, they represent the largest single computer based training system in the world, almost 1250 workstations. The two phase SENTINEL ASPEN program trains officer and enlisted personnel in general intelligence skills including imagery, targeting, reporting and analysis, and briefing skills. The two phased SENTINEL BRIGHT program trains enlisted personnel in cryptologic skills, including cryptologic language skills, electronic intelligence special signals, maintenance, and cryptologic analysis and reporting. This presentation addresses each system in detail, including design features, operating systems, authoring languages used, and in particular, unique functionalities. The pros, cons, and achievements of each system will also be discussed with emphasis on GTTC efforts to develop full interoperability among systems. Other areas of discussion are accomplishments to date in course and courseware development, lessons learned in the realm of developing courseware, development tools and teams, and the use of contractor support in the training development process.

MR. KENNETH CASPER Chief of the Computer Assisted Instruction Plans Branch at the 3480th Technical Training Wing, Goodfellow Air Force Base, Texas, received a Bachelor of Arts degree in Russian Area Studies from Fordham University in 1963, and a Master of Science degree in Education from the University of Southern California in 1970. A Colonel in the Air Force Reserve, Mr. Casper served over 11 years on active duty in a variety of intelligence assignments in Japan, Vietnam, and Germany, as well as in the United States. He has been a civilian training specialist at Goodfellow since 1982, holding the positions of Training Development Branch Chief of the Analysis and Reporting Training Division, 3480th Technical Training Group; Training Advisor of the 3495th Technical Training Group; and Training Manager in the Collection and Maintenance Plans Branch of the 3480th Technical Training Wing. He has held his current position since April, 1989.

ONE OF THE LARGEST COMPUTER BASED TRAINING SYSTEMS IN THE WORLD

Mr. Kenneth Casper

In the late 1970's, at Goodfellow AFB, Texas, a CAI training system was being designed to teach cryptologic linguists the knowledge and performance skills required of them at operational sites all over the world. In the traditional linguist training environment, students were required to listen to analog audio tapes of foreign languages, write short synopses of what they heard (write gists), and also write complete verbatim transcripts. The use of thousands of tapes on individual tape records for these tasks was both time consuming and distracting to students and instructors alike. Consider, for example, the necessary but essentially unproductive training time spent checking out and inventorying audio tapes, searching through those tapes for the appropriate training material, splicing broken tapes, and maintaining libraries for those tens of thousands of classified tapes. The method was time consuming, clumsy, distracting, fraught with security weaknesses, and inefficient. There had to be a better way.

Thus the Voice Processing Training System (VPTS), also known as SENTINEL BRIGHT program, was born. Several years later, its creators, learning quickly from their experiences with the still embryonic CBT world, developed a second phase to the program to teach a much broader range of intelligence and intelligence related technical skills. Thus, Goodfellow developed the SENTINEL BRIGHT I and SENTINEL BRIGHT II computer based training system for technical training.

About this same time training managers at Lowry Technical Training Center in Denver, Colorado, began developing a training course designed to teach imagery specialists of all four services and DOD, modern state-of-the-art digital imagery techniques. Incorporated in the new course was computer aided instruction (CAI). The program, owing to its place of birth, was called SENTINEL ASPEN. By the late 1980's, after realizing the ever growing potential for computer aided and computer based training, a second phase was also added to the SENTINEL ASPEN program as well. Like the second phase of SENTINEL BRIGHT, this follow-on phase was designed to train more generic general intelligence skills. Thus, SENTINEL ASPEN I, the General Imagery Intelligence Training System (GIITS), and SENTINEL ASPEN II, the General Applications Intelligence Training System (GAITS), programs were also established at Goodfellow.

These two SENTINEL programs may well have continued in parallel without too much interaction, had it not been for a decision made in the early 1980's by the Air Force to consolidate all Air Training Command (ATC) intelligence training at Goodfellow AFB. The result was more than just the relatively simple relocation of training courses and resources from Lowry Air Force Base, Colorado, Offutt Air Force Base, Nebraska, and Keesler Air Force Base, Mississippi to West Texas. There were really two objectives in bringing together all intelligence and intelligence related technical training to one

ATC center; economics was certainly one of them. This consolidation would not only be more cost effective in terms of resources, but would also allow for integration of the training itself. The synergism essential to the effective use of intelligence "in the real world" had long been recognized as a major deficiency in an otherwise effective technical training program. (See paper on SENTINEL CONCHO for more details.)

As a further natural result of this intelligence training consolidation effort, a long, careful look was taken by senior management at both the SENTINEL ASPEN II and SENTINEL BRIGHT II programs. Not unexpectedly, it was discovered that they had significant commonality. By the late 1980's, the SENTINEL BRIGHT II program was further along in development than its SENTINEL ASPEN counterpart, so when it came time for a full design and development effort to begin on SENTINEL ASPEN II, a conscious decision was made to make it a subset, a clone if you will, of SENTINEL BRIGHT II, with options for further functional development later on as additional requirements were realized.

Let me give you a more detailed description of the four SENTINEL programs at this point and then discuss the larger implications of their being collocated at Goodfellow AFB.

SENTINEL BRIGHT I, as already noted, is the Voice Processing Training System (VPTS). It is the oldest of the computer assisted instruction training systems at Goodfellow and is used to train qualified linguists the specialized vocabulary, analysis and reporting skills required to perform their specialized military duties. It was designed and built by Engineering Research Associates (ERA) of Vienna, Virginia. It came on line in 1986 and has been training intelligence and linguist specialties since then. The system is composed of 460 workstations broken down as follows: 385 student, 60 study hall, 2 systems operator, 10 courseware developer, 2 training administration, and 1 maintenance workstations. It should be noted that any of the student or study hall positions can be used for courseware development, even though only 10 are dedicated to it. The entire VPTS is served by five VAX 8600 mainframes pseudo-clustered to serve a varying number of classrooms and workstations. This "host" system was designed to overcome inherent single-point-of-failure disadvantages of a wholly clustered mainframe system. If a single VAX does go down for any reason, some workstations will be lost and some functionality of remaining workstations may be affected, but the entire system does not go down. This flexibility is an important consideration on a system that is used on a two shift operation, training students who are attending courses that are up to 22 weeks in length. This training system is based on 2 track digital audio with CAI and CMI used to guide, track, test, and remediate student interaction. Of 17,000 hours of linguist training available for conversion to computer based technology, 14,000 hours were selected for actual conversion. 12,000 of those hours have already been developed both by government personnel (civilian and military) as well as civilian contractors. The ERASMUS proprietary language developed specifically by ERA is used exclusively for courseware development.

SENTINEL ASPEN I, is also called the General Imagery Intelligence Training System (GIITS). There are two types of training workstations used in the GIITS systems, hardcopy and

softcopy. Both systems are downloaded by a central VAX 11/785 mainframe.

There are 60 hardcopy workstations each of which consists of traditional light tables used in conjunction with a single magazine quality imagery (MQI) display, a keyboard and a mouse. Imagery and courseware for the hardcopy course are downloaded from a VAX 11/785 mainframe to Micro VAX II mini-computer clusters, each serving up to four workstations. CAI functions include academic lesson delivery, testing, and training management functions such as student enrollment, test administration, and student records maintenance. Courseware is being developed in-house by government personnel using modified ISS (Instructional Support System), a government owned programming language.

There are 16 softcopy workstations (14 student, 1 instructor, and 1 authoring). A softcopy workstation consists of all the components of the hardcopy workstation plus a trackball, a shaftbox, and dual medium resolution terminals to display digitized MQI and courseware. The additional components are used to display and manipulate softcopy imagery on a 3M/COMTAL processor which replace the light tables. Advanced functions to manipulate the imagery (zoom, warp, mensurate, and gray scale) are incorporated in a sophisticated software package developed under contract. The SA I program, developed under contract by the Loral Corporation of Litchfield Park, Arizona, also includes 80 hours of contractor developed courseware for the softcopy course. Hardcopy and softcopy workstations are also used by authors to develop and deliver courseware concerning the exploitation of hardcopy and softcopy imagery respectively.

Like the VPTS, GIITS is VAX based, and uses the VMS operating system.

SENTINEL BRIGHT II (SB II), also called the Cryptologic Intelligence Training System (CITS), is the most advanced and ambitious computer based training system at Goodfellow. SB II, under development and delivery contract by American Systems Corporation (ASC) of Chantilly, Virginia, employs UNIX based, AT&T 6386 stand-alone, intelligent workstations using dual screen technology. Its capabilities, which far exceed the capabilities of any of our other computer based training systems at Goodfellow, include high resolution (1280 X 1024) touch screen, interactive video disk using MacDonnell Douglas laser film, and X-Windows. SB II will have a total of 386 generic workstations (some with specialized capabilities) as follows: 322 student, 32 instructor, 21 courseware developer, 6 system operator, and 6 training administrator workstations. They will be used to train four different intelligence specialties including advanced linguist training, cryptologic intelligence analysis and reporting, Electronic Intelligence (ELINT), and electronic equipment maintenance. All courseware is being developed by government personnel using the ACCORD development language. It has become the standard for Goodfellow CBT because of its state-of-the-art technology and virtually unlimited potential. It has therefore become the model for SENTINEL ASPEN II.

SENTINEL ASPEN II (SA II), also known as the General Applications Intelligence Training System (GAITS), is our newest CBT program. As noted above, following the standard of SB II, it exploits commercial off-the-shelf technology using high resolution color monitors for general intelligence

training. This interactive system program has 275 workstations as follows: 235 student, 18 instructor, 14 courseware developer, 4 system operator, and 4 training administrator workstations. SA II will focus on training general intelligence fundamentals and applications, targeting and weapons capabilities, indications and warning, intelligence correlation, and Command, Control and Communications Countermeasures (C3CM) courses. In its first phase, SA II is a hardware buy that is fully compatible with SB II and includes provisions for purchasing an additional 45 workstations for the SB II system. Phase two of SA II will add specifically developed functionalities and capabilities not already found within the SENTINEL BRIGHT II software package. Phase 2 will not begin until sometime next year (1992).

The combination of SB II's original 386 workstations, the additional 45 workstations under the SA II contract, and SA II's 275 workstations, which I call simply SENTINEL II, constitutes a fully compatible and interoperable system of 706 workstations. This is clearly our largest single CBT capability at Goodfellow. It's also the largest computer training system within ATC and, as far as we know, is the largest single CBT system in the entire Department of Defense.

Having three or four large computer based training systems at Goodfellow would perhaps not be of particular noteworthiness if it weren't for their size capabilities. But even more significant is the fact that, despite having two different operating systems (VMS and UNIX) and three different development languages (ERASMUS, ISS, and ACCORD), we plan to tie them all together into one interoperable CBT system. To further complicate matters, GTTC is also charged with creating exportable training, that is, training developed at the schoolhouse for independent use at non-ATC units. Because we are committed to satisfying customer training requirements for exportable training using their available resources, and almost all of our off-site users are limited to the MS.DOS environment, we are also required to develop modular courseware in the MS.DOS operating system. For this reason we are doing three things which will greatly expand the use of our training products.

First, we are actively pursuing the development of interfaces and other software products so that courseware we have already developed under one operating system is readily transportable to other operating environments.

Second, we are actively pursuing the enhancement and enrichment of the MERLIN authoring language to bring it up to the standards and capabilities of commercial, proprietary development languages and tools. MERLIN is a fully government developed and owned courseware development language. Its use will greatly simplify our courseware development effort, both at GTTC and in the field.

Third, under a concept program called SENTINEL CONCHO, we have designed a local area network (LAN) and installed a dual fiber optic ring at Goodfellow which we call the Integrated Intelligence Training Support System (IITSS). It not only makes transfer of information and courseware from one system to another possible, it also allows the individual training systems to receive information from

other outside sources such as national intelligence databases. As a result, we have been able to establish a Training Support Data Base (TSDB) which combines intelligence source data and other information in a format suited to the needs of our courseware developers and instructors. This TSDB allows the different training systems and courses to use a common database, further enhancing the interchange and use of training materials and data. Software is currently being developed to allow the ready exchange of this courseware without the requirement for extensive recompiling or reconfiguration. The end result will be considerable savings in courseware development time, effort and skills. This capability for the open exchange of training data and materials will also give Goodfellow an ability to modularize training for distance learning and exportable training, a major objective of the SENTINEL CONCHO concept of operations.

The creation of this huge CBT system has not been without its challenges. Essentially, we have faced three major stumbling blocks: courseware development, interoperability, and compatibility.

There is little I can add to what has already been said and written in these conferences and at many other such meetings about courseware development. It is expensive, time consuming, possessed of a steep learning curve, requires a team of dedicated, well trained specialists, and takes a change of mind set on the part of those doing it and those receiving it. We have, however, made what we believe to be significant progress in all these areas. We have developed more than 13,000 hours of interactive courseware on three of the four systems (the fourth isn't delivered yet!).

One of the most important lessons we have learned is that we, the user, really do know more about our requirements and capabilities than anyone else. That's not really the same as saying that we know it all. In fact, we hire experts when we need to, because they have the technical knowledge and skills we either don't have enough of or don't have at all. We use them to supplement our own capabilities, not to supplant them and they form an integral part of our team effort. They fill the gaps in our experience pool and we assist them in their development tasking, usually as subject matter and training experts. In that way we keep open the lines of communication and ensure that long hours of courseware development don't go down the wrong path. So far, the system has worked well.

We have also developed training courses to ensure our own home grown courseware developers are properly trained before they get thrown into that briar patch. In addition to faculty development courses in classroom instruction skills, test and measurement, and the Instructional System Development (ISD) process, government courseware developers take a 6 week course in CAI development, and an additional week's training in the particular development language they will be using. We have also developed a Style Guide for courseware development and have periodic cross-talk meeting with courseware developers from on-going projects. The net result is a well trained and well informed courseware development team concept that uses standards specifically designed for our training requirement and system needs.

Finally, there is the question of expansion and upgrade. SENTINEL BRIGHT I, the Voice Processing Training System, is fully meeting

our current training requirements both in the number of workstations and in the functionality of the system. Nevertheless, the system is limited and we are looking actively at alternatives for upgrading and expanding the system as the need arises. Since the SENTINEL BRIGHT II system (and its clone, SENTINEL ASPEN II) are currently at the leading edge of CBT technology, we are actively exploring mutual compatibility between them so that if it becomes necessary to expand the SB I system, or replace parts of it over the foreseeable future we can do so in such a way as to simultaneously expand the SENTINEL II system. We are also making a concerted, conscious effort to insure that any future systems or system upgrades are backward compatible so that existing courseware will not be lost or require redevelopment.

In summary, four major computer based training systems have been established at Goodfellow Technical Training Center in San Angelo, Texas for resident training of Department of Defense military and civilian intelligence specialists. These individual SENTINEL systems, comprising a total of nearly 1250 interactive workstations, are being joined on a fiber optic network called the Integrated Intelligence Training Support System. A vital part of this overall training development and delivery program, called SENTINEL CONCHO, is the Training Support Database being developed for the common use by students and courseware developers. In its totality, the integrated computer based training program at Goodfellow Air Force Base constitutes one of the largest computer based training systems in the world.

SENTINEL CONCHO

Today's challenges in intelligence training are not significantly different from the challenges in other technical training areas throughout the Air Training Command (ATC) or the rest of the Department of Defense (DOD). Except perhaps for the diversity, complexity, and security of the sources of the information, the current intelligence training environment can be seen as a microcosm of the full range of challenges being faced by the training establishment throughout government, business and industry.

Goodfellow Technical Training Center (GTTC) has developed a program called SENTINEL CONCHO to meet these challenges. Its goal is to insure more and better training to students both in the classrooms and on the job. SENTINEL CONCHO allows us to cope with course creation, courseware development, and resource management in an integrated, multi-source, multi-level, multi-technology environment. The program has three phases: (1) local integration of training and training systems, (2) distance learning and exportabe training to field locations, and (3) an integrated exercise network with outside organizations world-wide. The pioneering efforts being made in CBT configuration, interoperability, and integration under the SENTINEL CONCHO program will have a significant impact on technical training and education both in the government and the civilian sector for years to come.

COLONEL CHARLES L. ALDRICH Commander of the 3480th Technical Training Wing, Goodfellow Air Force Base, Texas, earned a Bachelor of Science degree in History from the United States Air Force Academy in 1969 and holds a Master of Arts degree in Chinese History from Indiana University. He is a Distinguished Graduate of Squadron Officers School and has completed Air Command and Staff College, the National Defense University's National Security Management course, and the Air War College. He graduated from the Naval War College Senior Course with distinction in 1987. Colonel Aldrich was trained at the Armed Forces Air Intelligence Center at Lowry AFB in 1970, after which he served at Tan Son Nhut AB, Republic of Vietnam. Other intelligence assignments included Langley AFB, VA and Headquarters Air Force, Washington, D.C. He returned in 1976 to the Air Force Academy where he served as Assistant Professor and Course Chairman in the Department of History until 1980. Later assignments included the North American Aerospace Defense Command (NORAD), Air Force Space Command, Headquarters, United States European Command, Federal Republic of Germany, the Intelligence Community Staff, and the Air Staff, Washington, D.C. He assumed his present position in July, 1991.

SENTINEL CONCHO

Colonel Charles L. Aldrich

In the early 1980's, the United States Air Force decided to consolidate all Air Training Command (ATC) intelligence training at Goodfellow Technical Training Center (GTTC), San Angelo, Texas. This decision was significant in several respects. It recognized that related training conducted by geographically separated and independent organizations is inherently uneconomical, resulting in duplication of effort in course development and inconsistency in training delivery.

Intelligence training, like training in other highly technical areas, had become fragmented over the years, not as an intended result of coordinated decision making, but as a by-product of isolated decisions, each of which made good sense in itself, but which over time and distance lost their potential effectiveness. By the late 1970's the inefficiency and the ineffectiveness of this fragmentation, had become apparent. Military commanders in operational decision making positions were clearly stating that fragmentation was more than just an inconvenience; it was having a detrimental effect on the quality of training their intelligence officers and enlisted specialists were receiving. Supervisors in the field were compelled to spend more of their very limited time and resources developing, delivering and administering training, and sometimes retraining technical school graduates in basic skills. Fragmentation was also inhibiting the long term goal of fielding more rounded, better qualified professional intelligence personnel. Intelligence training consolidation was therefore conceived as a two step process: physical collocation, and then integrating the training of the various intelligence disciplines themselves.

The first step, collocating existing ATC intelligence technical training courses to Goodfellow Technical Training Center (GTTC), involved moving training elements from Keesler AFB, Mississippi, Offutt AFB, Nebraska, and Lowry AFB, Colorado. Doing so made good economic sense since the classified nature of the course contents necessitated the establishment of "secure" training facilities. Collocating the courses meant that facilities could be shared and that the inevitable duplication of effort, especially in the area of common courseware development and training administration, could be minimized, or perhaps completely eliminated. The resulting collocation and consolidation of management resources also meant manpower savings and a more efficient organizational management structure.

As noted above, the decision to consolidate was not solely the result of economics. There had been a growing perception in the intelligence world that intelligence training, while admittedly meeting the letter of carefully defined training requirements, was not meeting the greater--largely implied--need to produce well rounded specialists who could both see and understand the global environment of their skills. The murmur of "good, but not enough" wasn't a new one, nor, in fairness to the people who had been producing intelligence training for many years, was it unique to the intelligence community. The same call to "give us more" could be heard in virtually every career field. What could not be ignored was the equally persistent economic

fact that training time could not be significantly expanded to meet growing training needs and desires. We soon realized that we were not being asked to train more so much as we were being asked to train better.

As it turned out, the decision to consolidate intelligence training at Goodfellow came at an extremely fertile time. The burgeoning science of computer technology was opening new vistas in computer capabilities, flexibility, size downscaling, memory expansion, and--most significantly--applications software in fields only vaguely explored in the past. Although it would still be several years before the full potential of computers was realized in the training world, Goodfellow had already awakened to this potential in the cryptologic linguist training area. By the late 1970's, Goodfellow had designed a computer assisted instruction (CAI) training system called the Voice Processing Training System (VPTS). This was the first step in modernizing all cryptologic intelligence training conducted at Goodfellow. The overall program was called SENTINEL BRIGHT and the VPTS was called SENTINEL BRIGHT I. In its original form, SENTINEL BRIGHT I was designed to upgrade the equipment and equipment handling of the language training programs at Goodfellow. It certainly succeeded in doing that, but it also did much more. It turned out to be only the first step in revolutionizing the way technical training itself is designed, developed and delivered, and it opened the door to three other computer based training systems at Goodfellow. Over the next ten years, what started out as little more than the seed of an idea, a way to let computers handle mechanical and training management tasks more efficiently, blossomed into one of the largest computer based training systems in the world.

The collocation of intelligence training courses and resources at GTTC was completed on schedule, in July, 1988. It was accomplished without a single training day being lost, a not so insignificant achievement, when one considers that nearly one hundred courses and almost two thousand students a day were involved. The largest share of these transferred courses and students came from Lowry AFB in Denver, Colorado. With them also came another germinal CBT system, an imagery based training system designed to present imagery analysis students training using film (known as hardcopy), and computer generated imagery (known as softcopy). This General Imagery Intelligence Training System (GIITS) turned out to be only the first step of a much more ambitious program called SENTINEL ASPEN, a program designed to modernize all non-cryptologic intelligence skills training at GTTC.

The second step in the intelligence training consolidation process, and by far the more ambitious and challenging part of it, was integrating the collocated intelligence training programs. By 1988 it was patently clear to everyone that the heart of this all encompassing and intensive training project could only be the computer. Our ultimate goal at GTTC was to go beyond merely teaching and testing the finite, relatively easily measured skills and knowledge of esoteric intelligence specialties. Our real ambition was to create an intelligence training center of excellence that revolved around a cohesive, interlocking computer based training environment. We called this program SENTINEL CONCHO.

SENTINEL CONCHO is more than just the program title of another interactive, computer-based training system. It is designed to provide a coordinated and well integrated intelligence training

environment for apprentice and advanced level students. Its goal is more than just better individual training courses in specialized areas. The new training architecture is intended to create a shared learning experience by officer and enlisted students, a common reference point that culminates in professional interaction among several intelligence disciplines.

SENTINEL CONCHO is being implemented in three phases. These phases are basically independent of each other but they are far from being exclusive of each other. Elements of one phase become part of another phase, but they are not sequential.

Phase I is Local Integration.

We have designed and installed a local area network (LAN) called the Integrated Intelligence Training Support System (IITSS). This network, which is composed of a dual fiber optic ring and a series of coaxial subnetworks, permits the exchange of data among our four host CBT systems through file transfer, electronic mail, and virtual terminal. We have also created a Training Support Database (TSDB) which will be used as a common, all-source, integrated intelligence information database for all cryptologic and general intelligence training development. The long term economic advantages of this design are obvious. Academic courseware developed in one course on one system can be used by other courses on the same system or on other systems. Duplication of effort is signficantly diminished, not only in the initial creation of courseware, but also in updating it because updates can be done globally to the same lesson in all courses. Because the source data for all courseware development is the same for all courses, the plague of inconsistency in data among courses, will also be overcome. In short, all students will have reference to the same big picture.

As noted earlier, the SENTINEL CONCHO concept will revolutionize technical training in the intelligence arena. Basic skills have been and will continue to be the first priority of technical training. But SENTINEL CONCHO creates a truly integrated training environment which puts these skills in context from the first day of training and which allows the professional intelligence specialist to grow both in breadth and depth of understanding.

At the beginning of training, all students will be shown the same scenario depicting a representative intelligence situation in a realistic intelligence operations environment. The scenario may be a reenactment of a real situation, e.g. the shootdown of KAL flight 007, or it may be a fictitious (but realistic) situation. In either case, the scenario will focus on the actions, reactions, and interactions of intelligence specialists across the entire spectrum of the career field and up and down the career ladder.

Let me give you a quick example.

At a particular military site, the commander has just learned about a critical situation developing within his area of responsibility. As the combat commander, he requests a current intelligence briefing on the situation. We see a team of intelligence specialists do research after which an intelligence officer (AFSC 8075)

briefs the commander and his staff. Questions are asked by them. The intelligence officer answers those he can and takes those he can't as tasking for further research. At the same time intelligence reports are being received from various intelligence sources. The picture shifts to the sources of those reports. We see particular, clearly identified intelligence specialists collecting, analyzing, collating and reporting information and we see how the reports are handled at various echelons. The crisis develops and we see the vast array of actions that result. Most importantly, we see particular intelligence specialists actually doing their work.

Students will see how their own particular specialties function in the situation, but since the scenario includes all the other intelligence functions, specialties, and disciplines which can reasonably be expected to be found in such an environment, the student also gets to see how each of them operates in common circumstances.

The student will then receive the specific, criterion-referenced technical training required for his intelligence specialty. That content of technical training will not be much different from what he/she receives now, but the method of delivery will. CBT improves quality of training by making it interactive and focusing on the student rather than the instructor. Ideally the medium of training is transparent to the student. In fact, we know it isn't. Computers will at least make it more interesting and challenging to the student--a good motivator in itself. What will also be different from the training of the past will be that training for particular intelligence specialties will be consistently and repeatedly referenced back, through a series of "out-takes" to that same common scenario that all the students viewed at the beginning of their training. The preponderance of these out-takes will be to satisfy specific training standard objectives. In some cases, however, students will receive non-testable orientation and education on other intelligence specialties. This will give them a more objective view of where their specialties fit within an intelligence organization. It will afford all students a common point of reference in training; it will eliminate the feeling that they operate in isolation; and hopefully it will also motivate them to learn more about their own specialties and about their colleagues' specialties.

In initial skills training courses for apprentice intelligence specialists, non-testable "out-takes" will naturally be limited in number and scope. For example, linguists might be introduced to analysis functions which closely parallel their own duties, especially in areas where they would be expected to interface or work together at an operational site, but they would not receive very much exposure to imagery analysis skills or duties.

While apprentice level training has been the main focus of ATC resident training in the past, and will remain so for the foreseeable future, we do have some advanced, and supplemental training courses at Goodfellow. Later on I will discuss distance learning and exportable training, but for now let me just say that the advanced and supplemental intelligence courses we have at Goodfellow will be progressively more integrated. All courses will retain discipline dominance; however, skill-driven problems will be based on the integration of multi-source intelligence, and include the production of finished intelligence products. All applicable supplemental-level courses will play an end-of-course integrated

exercise in a scenario generated by the tactical simulation program. In this way, more experienced intelligence specialists will be exposed to other intelligence related specialties which are not as readily apparent. For example, an imagery analyst may learn the rudimentary principles of aircraft tracking, or a targets officer might learn more about the sources of data from which targets have been selected.

I mentioned tactical simulation a moment ago. Obviously, this entire program is heavily dependent on being able to simulate actual conditions students can expect to find when they reach their assignments. Part of that simulation capability resides in a program called Tactical Simulation or TACSIM. TACSIM provides the backbone for exercises which simulate real-world operations through scenarios that model enemy (red force) and friendly (blue force) positions and movements. Raw intelligence data, that is, unverified, unevaluated information, and finished operational and intelligence reports, that is, reports of verified, or evaluated data, are used by students to assess battlefield situations. The resulting student analysis and reporting directly impacts red force posture and movement, thereby providing integrated training for all intelligence disciplines. The TACSIM program allows courseware authors and instructors to tailor scenarios in a variety of conditions and circumstances. These exercises can be discipline specific or they can be multi-discipline integrated exercises. Its tremendous value, of course, lies in its ability to allow students to interact in a simulated situation by maneuvering forces, requesting additional reconnaissance reports and air strikes, and reviewing and processing collected intelligence.

At the end of all courses, students will again be shown the same scenario that was shown at the beginning of the course in order to reinforce what they have learned, give them a better appreciation of the other disciplines with which they will be working, and show them how the skills they have learned fit into the environment in which they will be working.

Phase II is Exercise Integration.

This phase is composed of two integrated communications networks:

Intelligence Training Network: We've seen how we can eliminate duplication of effort in training development at Goodfellow by integrating our training resources and creating a Training Support Database. But Goodfellow isn't the only intelligence training center. The Army and Navy have theirs, as well as other intelligence and intelligence related agencies. We don't intend to pass up the opportunity to use what we can of their training development efforts. We also want to share with them what we have developed. A communications network will therefore be created between the schoolhouse and other DOD training activities: Ft Huachuca, AZ (Army), Dam Neck, VA (Navy/Marines), and the Defense Intelligence College (DIC) in Washington D.C., among others, in order to further the exchange of intelligence training materials. There's also another aspect to this. With this kind of connectivity with other training centers, we can also participate in joint training exercises. A link between GTTC and the Air War College at Maxwell AFB, AL, could also promote interaction between Intelligence and Operations game planning. These exercises will serve two very important but up until now unattainable objectives:

1) Furnish a vehicle for intelligence personnel to exercise critical intelligence contingency skills related to their current positions.

2) Allow intelligence personnel to participate in appropriate but not frequently experienced scenarios in order to expand their experience base.

Operations Exercise Network: A communications network will be created between the schoolhouse and elements of the intelligence community. Interaction will be comprised of exercises which may be schoolhouse driven or may be piggy-backed off exercises driven by other agencies (e.g. the Joint Chiefs of Staff). The purpose of this interaction is two-fold:

1) Furnish training and experience to intelligence personnel in the operational environment in aspects of intelligence which their everyday duties would not normally afford them. This will maintain and reinforce the "integrated" nature of their awareness and make them more valuable and more flexible intelligence experts.

2) Provide feedback to the schoolhouse on changes taking place within the intelligence community that will give it an opportunity to update and upgrade its in-house and exportable intelligence training.

Phase III is Distance Learning.

Resident training is expensive. Its cost has inhibited us in the past from giving more advanced and lateral training courses to intelligence specialists, especially for personnel stationed overseas. The combination of teleconferencing technology and computer-based training developed at GTTC offers an economically feasible alternative to resident training. Thanks to satellite communications, intelligence personnel at operational units will be able to receive formal training without having to leave their units. Some of this training will be in direct support of the individual's supervisor by supplementing on-the-job training (OJT) programs. Some will train already experienced intelligence specialists in new systems and technologies; others will train and certify personnel in multiple intelligence skills. Clearly, distance learning gives us the opportunity to expand the breadth and depth of the intelligence skills pool. In addition to technical skills, exportable training affords opportunities for advanced courses that focus less on technical skills and more on critical thinking. These will include mid-career intelligence courses for officers, NCOs, and civilians to refresh, update, and expand their skills, and remotivate them.

Under SENTINEL CONCHO, we can now train intelligence personnel in an environment which gives them not only specialized intelligence skills, something we have been able to do for many years, but more importantly a new awareness and appreciation of the functions, duties, and responsibilities of other intelligence functions. For the first time, we will be able to show students how their combined skills and actions contribute to the intelligence mission of the Air Force and the other military services, and how they individually and jointly form a real community of professionals who have a very real impact on the national defense. We believe that through the SENTINEL CONCHO concept we will be able to foster a growing interaction among intelligence specialists. We see in the future more and better interaction between

intelligence officers within their own disciplines and between them, and we see a closer working relationship between officers and enlisted personnel at every level based on a professional understanding of each others talents and skills. In short, we are striving to produce a more cohesive, interactive relationship among all intelligence disciplines.

We're certainly not there yet. We have a variety of goals and tasks to accomplish over the next few years. For example, we have to develop scenarios around which specialty training can be focused. These scenarios must be credible and representative of what is currently available in the operational environment. We need to identify common subject areas among all intelligence training courses and define training levels required for common non-specific skill training (e.g. security, safety) for students within intelligence courses. And we must develop and implement common course materials for common subject areas.

We then have to implement the IITSS so course materials developed for one system can be transferred and used in other systems. From that combined, unified, consolidated courseware database we can develop exportable (Type 6) CBT training materials that are compatible with field site operational and training equipment (hardware independent).

We also have some long term goals that are intensively technology dependent. For example, we will have to design and implement the training and operations world-wide networks for the interactive exchange of training and exercise materials. A major stumbling block in this arena will be the resolution of security access problems associated with multiple levels of world-wide, interactive intelligence information. We must develop courseware and courseware delivery tools that make the computer based integrated intelligence training system user friendly. But perhaps one of the most important things we have to do is work closely with our customers to insure they are fully and properly stating their training requirements, not just in terms of technical knowledge and skills, but in terms of the global environment.

Finally, computer based training is not simply a better, more efficient way of doing the same old job of training. It gives us a chance to go far beyond finite, parochial specialism. CBT gives us opportunities we never had before, opportunities for remediation, for flexible, objective testing, and for global environment presentation of specialist and technical training.

In summary, SENTINEL CONCHO is the vector for the integration of intelligence training. In this capacity it establishes training policy and the content of the integrated training environment it needs to produce the best qualified apprentice intelligence specialists possible. Specialists will be trained in the shortest possible time to perform basic intelligence skills better than their predecessors of only a few years ago. More than that, they have the tools to develop into the most highly qualified professional intelligence specialists and technicians ever produced by Air Training Command.

IN-HOUSE COMPUTER BASED TRAINING (CBT) PROJECT

FOR

AIR FORCE ACQUISITION SUPPORT SYSTEMS ENGINEERS

Abstract. There is a significant need for engineers at Aeronautical Systems Division (ASD) who understand all aspects of CBT development. A CBT project was initiated in order to provide an effective method to train engineers. Twelve home office engineers were assigned the responsibility to develop the following courses: CBT Systems, CBT Request for Proposal (RFP), CBT Source Selection, and CBT Contract Execution. These training courses have been delivered initially to at least twenty direct program support engineers. This paper discusses the project, and lessons learned for similar applications.

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Introduction

The Computer-Based Training (CBT) Project grew out of the increasing scope of Air Force training system acquisitions. The Aeronautical Systems Division (ASD) traditionally procured only training system components for a new weapon system. Now, with advances in training system technology, the responsibility for integration of the training system is shifting from the using command to the implementing command, AFSC. With this shift has come new areas of concern largely associated with courseware. One of these areas of concern is CBT. Engineers have had to adjust to this shift and get their feet wet in the "soft science" of courseware design, particularly for CBT. However, a vehicle for instruction was not readily available. The Tactical Air Command (TAC) Computer-Based Interactive Training System (CBITS) contract opened up an avenue.

Project Background. The Training Systems Division, ASD/ENET, responsible for support of any proposed training system acquisitions, recognized an opportunity to gain needed project experience for young engineers as well as develop economically the training courses necessary to prepare support systems engineers for the courseware aspects of their jobs. CBITS would be the vehicle for training development and delivery. The Training Systems System Program Office (SPO), ASD/YW, agreed to fund and procure three advanced CBIT Systems expecting to receive the benefit of the courses to be developed. Twelve training systems engineers, military and civilian, were assigned (part time) to the CBT project. Initially, these engineers agreed to develop four courses on CBT acquisition: CBT Systems, Request for Proposal (RFP), Source Selection, and Contract Execution. The CBT Systems course was to describe the hardware, software, and courseware that can be configured for a CBT system. The sequential RFP, Source Selection, and Contract Execution courses were to follow the acquisition of CBT from the establishment of the requirement to the delivery of the system to the ultimate user. The target audience for these courses was identified as training project support system engineers assigned to the Training Systems system program office.

CBT Project

The CBT Project was initiated in June 1989. Engineering approval was achieved by July, funding in August, and the equipment was on contract by September. The CBT Project schedule is shown in Figure 1. The project schedule was laid on top of the existing workload. A program manager was designated, but access to project personnel was through three branch chiefs. The Division Chief set the project priorities and received periodic progress reports which he, in turn, reported to the Technical Director. Leadership changes did occur during the project, but the program manager remained constant. The program manager directed the project and adjusted to shifts in philosophy. Project personnel were established early, but several were lost to other programs during the period of the project. The relative inexperience of personnel working on the project meant increased time for learning efficiencies and understanding how to use capabilities such as the graphics editor and the training management function. By far the most difficult problem driving the schedule was obtaining agreement and approval on course content.

Project recommendation	12 Jun 89
Engineering approval	28 Jul 89
Funding approval	14 Aug 89
Equipment on contact	26 Sep 89
Authoring software training	15 Oct 89
Computer-based instruction training	20 Jan 90
Preliminary design review	16 Apr 90
Equipment delivered	20 Apr 90
System design review	10 Jul 90
Final management/engineering review	26 Oct 90
Ready for Training	1 Nov 90

Figure 1
ASD Computer-Based Training (CBT) Project Schedule

The initial understanding of the course content was so general that when the engineers began their design process, boundaries had to be set. How much review of basic acquisition principles was necessary? What was the process for a CBT acquisition as opposed to a training system acquisition? What was the relationship of courseware reviews to traditional hardware and software engineering reviews? In the process of establishing course content, an acquisition process for CBT courseware was derived. See Figure 2. Coming to agreement was time consuming, but brought into focus where the CBT acquisition process needed definition. Another concern was how to communicate this definition to the engineers implementing the courseware development process. Resolving this concern led to the addition of three other lessons to the project: Introduction, Features, and Technical Overview.

Courses. The resultant set of courses for the CBT Project was three introductory lessons and four courses on CBT and the CBT acquisition process. The Introduction lesson presents CBT issues in the systems acquisition process. This lesson assumes the engineer already understands the systems acquisition process. The Features lesson is a demonstration of the hardware, software, and courseware available for CBT along with the developmental features of the system for the CBT Project. The Technical Overview lesson provides a basic overview of CBT and the relationship of CBT within a system acquisition at ASD.

The four primary courses begin with the CBT Systems course, which covers the purpose, operation, and distinct features of CBT hardware and software. The next course, CBT Request for Proposal (RFP), identifies the primary issues during RFP preparation (limited to CBT acquisition). The Source Selection course focuses on the technical concerns during the selection of a CBT system. The Contract Execution course covers the areas of attention required to monitor a CBT contracted effort. These courses review the instructional systems development (ISD) process and relate the ISD process to the systems engineering process for a CBT acquisition. It takes approximately 8 hours to accomplish all of the introductory lessons and primary courses.

Equipment. The CBT system purchased for the CBT Project was based on the CBITS configuration. Adjustments were made to enhance the system with the most current releases of hardware and software. For example, the computer was upgraded to a Zenith 386 (was Z-248), the Quest authoring system was upgraded to version 3.0 (was 2.41). Project personnel had the opportunity to be heavily involved with Quest 3.0 Beta testing. A block diagram of the CBT Project system is shown in Figure 3. A brief word description of the system capabilities is shown in Figure 4.

Integration. Integration of all necessary CBITS components plus the enhancements caused difficulty. The estimated amount of memory required was shortsighted. The VCR was not directly controllable from Quest software. Adding the laser disk along with the VCR required the writing of independent drivers.

Cost. Three CBT systems were purchased at a cost of $111K. In addition, a quality television camera system with editing capability was purchased for $24K.

SRR	TSR	PDR	CW CDR	PRODUCTION	T&E
Review Training Objectives	Approve Objective Hierarchy			Code & Debug	
Discuss Course Syllabus	Approve Course Syllabus				
Discuss Test Plan	Discuss Test Plan	Discuss Test Plan	Discuss Test Plan		ITO SGTO CRR
Begin Formative Evaluation					
	Review Style Guide	Discuss Style Guide	Finalize Style Guide		
	Discuss Lesson Outlines				
	Discuss Flow Diagrams				
	Discuss Lesson Spec Format	Discuss Lesson Spec Reviews	Approve Lesson Spec		
	Discuss Storyboard Format	Discuss Storyboard Reviews	Approve Storyboards		
	Plan Prototype Lessons	Review Prototype Lessons	Approve Prototype Lessons		

Legend

SRR—System Requirements Review
TSR—Training System Review
PDR—Preliminary Design Review
CRR—Course Readiness Review
T&E—Test and Evaluation
CDR—Critical Design Review
CW—Courseware
ITO—Individual Tryouts
SGTO-Small Group Tryouts

Figure 2
Acquisition Process for Computer-Based Training (CBT) Courseware

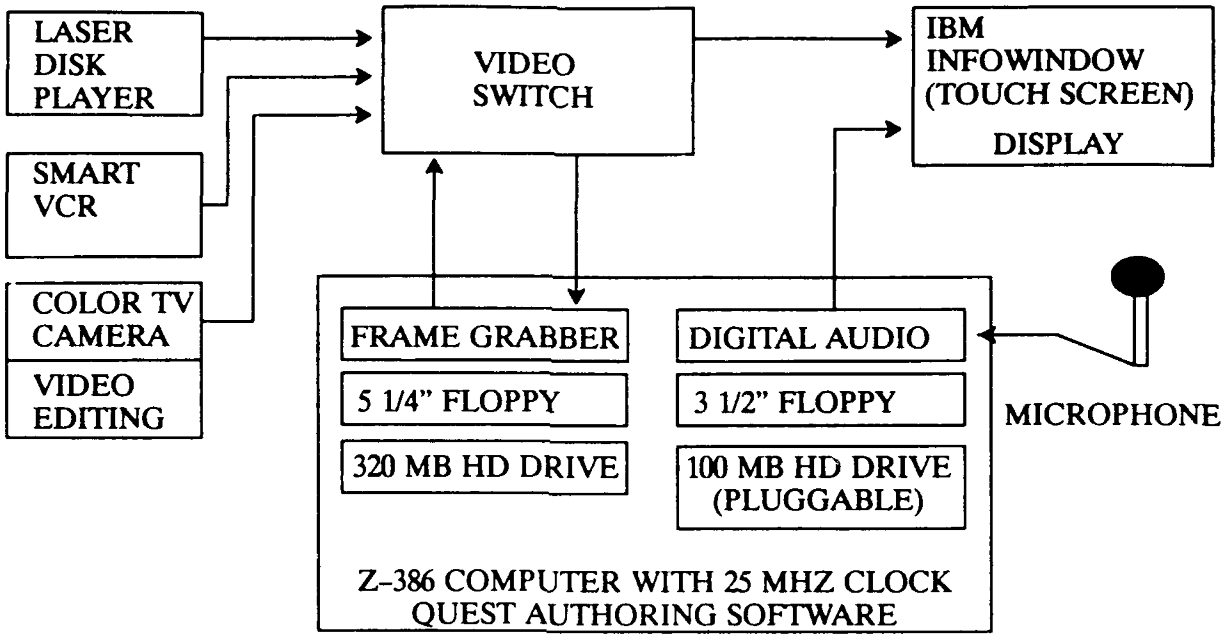

Figure 3
ASD Computer–Based Training Project System

COMPUTER:	Z–386 with a 25 MHZ clock	DOS 3.3+
	328 MB Internal Hard Disk	386 to the Max Memory Mgr
	109 MB Pluggable Hard Disk	Mouse
	3 1/2 inch 1.4 MB Floppy	5 Slot Expansion Chassis
	5 1/4 inch 1.2 MB Floppy	640K + 1024K RAM
DISPLAY:	IBM Info Window with Touch Screen and Voice Synthesizer	
OTHER FEATURES:	Frame Graffer	Color Printer
	Digital Audio	Laser Disk Player
	Arts and Letters Graphics Editor	Image Scanner
	Quest Authoring Software	Desgview
	Ethernet Card (Not Connected)	T-EGA
	525 Line Color TV Camera System with Full Edit Capability	PC Paint

Figure 4
ASD Computer–Based Training Project System Capabilities

Results/Lessons Learned

The definition of an acquisition process for CBT courseware (Figure 2) was a milestone for this project. The meeting of the minds between team members from multiple technical disciplines required an understanding of one another's vocabulary and recognition of the similarities and differences in how to approach the same problem. The real melding came with the integration of the instructional system development process with the systems engineering process description. Now the relationships are established and integrated product development is facilitated.

The changes in leadership over the course of this project required flexibility. Each change shifted the attention of team members, adjusted the scope of the project, and focused on concerns raised that now needed to be addressed. The narrow scope on just CBT acquisition required a venture into an arena not experienced by most members of the team. Looking back, the definition of the training requirement needed more formalization and the scope of the work effort suffered from changes in leadership.

A second major category of lessons-learned involves the need for a firm process with clear lines of authority. This is especially necessary when a CBT project is done "ad hoc," with part-time help from many organizations. Just like a CBT project done by industry, we wrestled with firm specs, milestones, reviews, integration, and perhaps most importantly, content integration.

The opportunity of carrying out an in-house project gave the young engineers on the team a real program experience. The learning-by-doing drew out lessons learned that could never be gained in the classroom. The whole process of getting the CBT system operational, learning how to use it, and then independently developing courses which would integrate into a composite set was a challenge in and of itself. Then, living under the pressure of time to delivery and at the same time working under the scrutiny of multiple levels of review, feedback, correction, then repeat the cycle, brought a feeling of reality; this is what it is like to meet a program deadline. The joy of an on-time delivery had real significance.

The ability to carry out an in-house project with limited resources on top of existing commitments and any new commitments taken on during the course of the project was an extra challenge for the program manager. The team effort required the support of the formal organization to establish the right priorities and then make the commitment to follow through with the project. With the formal organization enforcement, the program manager had the authority he needed to carry the project to conclusion.

The good start of CBT instruction on developing courseware in general and on development using the Quest Authoring System made a significant difference in the ability of the team to carry out the project. The variety of past experience tied to this foundation of instruction made a strong team. The skills were there. The difficulty was keeping those trained in place long enough to do the job. In a few cases, members of the team who had been drawn away for other programs were brought back to address specific issues and work through problems blocking progress. The schedule was set up from the beginning, knowing that adjustments would need to be made, lessons would be learned, and problems would arise that would cause tasks to take longer than expected. This built-in time allowed the flexibility needed throughout the course of the project.

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   Sheppard Technical Training Center
   3700 Technical Training Wing
   Sheppard Air Force Base, Texas, 76311-5000
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   Allen Communication, Inc.
   140 Lakeside Plaza II
   5225 Wiley Post Way
   Salt Lake City, Utah 84116

TECHNICAL

USING HYPERTEXT IN COMPUTER ASSISTED INSTRUCTION

Ron W. Rhoads, C. G. Thronesbery

Hypertext is an emerging technology which allows the user to create linkages among text, graphic, numeric, and other data sets. Systems are being designed which will provide the instructional designer with the capability to create a linked set of instructional materials.

Once this linked set of materials is created by the designer and developer, it can be tailored to the specific instructional setting. The material can be individualized for the student by deleting or creating links within the existing materials. This tailoring ability provides the designer and developer with a powerful tool to address specific training problems. Tailoring of instructional materials can include linking to the necessary background material for remediation when necessary. In addition to this, all background material (job and task analyses, media selection tools, adjunct instructional material, etc.) can be linked within a structured presentation format.

An application of the emerging technology of hypertext to computer-assisted instruction is described. Specific system designs are provided for a computer system which illustrates the development of the presentation system. With the proper Macintosh equipment, a demonstration of the system can be provided.

R. W. RHOADS

Mr. Rhoads joined Hughes Training Systems, Inc., in Arlington, Texas, as an Instructional Designer in September of 1990. He is currently performing a requirements analysis for a company-wide Training Administration System. Earlier, he was employed with LB&M Associates developing hypertext systems. He and Dr. Thronesbery have developed an extensive hypertext system (the Corps Operations Decision Aid, or CODA) which contains information from Army Field Manuals.He worked in the Ft. Sill Area for ten years as a project manager, systems analyst, human factors engineer, and training analyst, for military software systems, including the Tactical Fire Direction System (TACFIRE), Advanced Field Artillery Tactical Data System (AFATDS), Battalion Battle Simulation (BABAS) TACFIRE Training System (BTSS), Corps Operations Decision Aid (CODA), and ARDEC Laboratory Decision Support Systems. He has an M.S. in Educational Technology and a B.S.E. in Science Education from the University of Oklahoma.

C. G. THRONESBERY

Dr. Thronesbery joined The MITRE Corporation as a Member of the Technical Staff, in support of NASA at Johnson Space Center, in September of 1990. Earlier, he was employed with LB&M Associates developing hypertext systems. He worked in the Ft. Sill Area for seven years as a systems analyst, human factors analyst, and training developer, for military software systems, including the Tactical Fire Direction System (TACFIRE), Advanced Field Artillery Tactical Data System (AFATDS), Battalion Battle Simulation (BABAS) TACFIRE Training System (BTSS), Corps Operations Decision Aid (CODA), and ARDEC Laboratory Decision Support Systems. He has a Ph.D. in cognitive psychology from the University of Houston.

USING HYPERTEXT IN COMPUTER ASSISTED INSTRUCTION

R. W. Rhoads, C. G. Thronesbery

1. Introduction

Hypertext is an emerging technology which allows developers to create linkages among text, graphic, numeric, and other data sets. Systems are being designed to provide instructional designers with the capability to create multi-linked packages of instructional materials. These linked instructional packages can be tailored to a specific instructional setting or individualized for a student by deleting and creating links within the existing materials.

This tailoring ability provides the designers and developers with a powerful tool to address specific training problems. Tailoring instructional materials includes linking more detailed background material for remediation, linking organizational material for the student (such as hand-outs or a course syllabus), and linking evaluation tools like pre-tests and post-tests. All background material (e.g., job and task analyses, media selection tools, adjunct instructional material) can be linked within a structured presentation format.

Thus, hypertext technology provides the capability for easier and quicker access to information, and providing a more highly structured information base. These two advantages translate into more efficient design and building of computer assisted instructional materials. This paper applies the theme of this year's conference to show two strategies for using hypertext technology.

2. Overview of Hypertext

Hypertext is normal text which has had links added to increase the accessibility of the information. These links are normally added at document construction time and are part of an overall organization of the information being dealt with. Typically, these links can be placed between text and text, text and graphics, graphics and graphics - just about anyplace where a direct conceptual tie is necessary or desired. The resulting hypertext document is one in which the access to information is made quicker and more efficient.

Recent months have seen an explosion of available tools and packages for developing hypertext applications. These range from the highly graphic and multifunctional SuperCard which runs on the Apple Macintosh to the mostly textual and simpler HyperTies which runs on a PC. For a more complete discussion of the tools available, see Conklin (1987) and Shneiderman & Kearsley (1989).

With all these tools, the significant factor in the design and construction of instructional materials is that they can be used to build and change highly complex informational structures quickly. This capability provides the developer with the ease needed for adapting generic materials to individual students.

A generic instructional systems design process involves, in one form or another, the processes of analysis, design, development, implementation, evaluation, and feedback. The capabilities of hypertext can be exploited to increase the efficiency of performance in each of these phases.

- During the analysis phase, when job and task analyses are completed, a hypertext system can be used to link related tasks, training objectives, evaluation instruments, and adjunct background materials.

- During the design phase, a hypertext system can be used to link together those major portions of the training materials to be developed (i.e., lesson plans, training manager's guide, student hand-outs, exercises, etc.).

- During the development phase, a hypertext system can be used to track and document the system being built. This means that the documentation for a computer generated paper-based system can easily be converted into a CBT system. It is a simple matter to use the digital version of documentation developed as a source for CBT presentation. This can be accomplished by creating the links necessary to use the source information for the frame presentations.

- During implementation/evaluation/feedback phase(s) a hypertext system can be used to archive older versions of the system, how those versions have been altered based on feedback, what that feedback means, the source of the feedback, and the nature of the alterations.

Although more elaborate instructional design tools are possible (see Thronesbery & Rhoads (1991)) this paper addresses the application of one specific aspect of the use of hypertext systems; the use of hypertext document bases as a means for delivering an on-line course syllabus and subsequently on-line individualized remedial instruction packages.

3. Hypertext Instruction

As described by Thronesbery & Rhoads (1990a), Rhoads & Thronesbery (1990), and Thompson & Thompson (1987), the use and access of information is greatly enhanced when it is linked conceptually. Large informational data structures of this type, when used as a set of course reference documents, must be presented to the students in a manner that is understandable and instructional. This means that the material must be ordered to match the sequence of instruction in the class or within the computer assisted instructional units. And it means that the material must be selected (or excluded) based on its relevance to the needs of the class and the individual students. See Figure 1 "A Structured Hypertext Document Set" for a generic representation of a set of linked documentation.

With a fully developed document package, the process of individualization is a matter of analyzing the specific learning style of the student, accommodating the content of the course, and evaluating the presentation modes of the material (the basis of the concept embodied by hypermedia presentations). This linkage technology is discussed in detail in the paper by Thronesbery and Rhoads in this volume. The addition or deletion of links as necessary will enable an instructor to construct an individualized learning package which uses the specific course content, but with the proper links to background or remedial material that fit the needs of the individual student. Instructional packages structured in this manner can bypass course content the student has already mastered. The linked materials can be structured to contain additional remediation materials which were not a part of the original course syllabus. These structured hypertext instructional systems optionally can contain additional exercises, evaluation instruments, and enrichment material.

Instructors (or instructional designers) will also want to use the capabilities of the system to construct a course syllabus by extracting and linking materials for general classroom use. By selecting and linking various book chapters, journal articles, lecture summaries, classroom exercises, and any other desired related materials, an instructor can construct a course syllabus which can be made available on-line to the students. This on-line syllabus can be linked to the material which is generally available to the student as instructional materials as a part of the computer-assisted instruction. By doing this, the instructor has provided the student with a set of easily accessible materials which are indexed to the CAI lessons and form the bulk of the required reading/research materials for the class. See Figure 2 "Using the Linked Information".

The Developer of the system will be making decisions about the structure of the material to be included in the system, the specific content of the material to be included, and the level of detail necessary to meet the instructional objectives. This means that the Developer will be asking questions like:

- "Does this reference text provide a better description of the material than any other?"

- "Is this particular article written in a manner that can be understood easily by students at this level of instruction?"

- "Is this material relevant to the student's needs at this point in the instructional sequence and should it be included?"

- "How does this material relate to the overall course and the sequence of presentation to the student for increased understanding and internalization of concepts?"

- "Is this material too complex or too simple to be of any use to the student as primary information or as background information?"

4. Tailoring Hypertext Instruction

Consider the previously referenced diagram, Figure 1 "A Structured Hypertext Document Set", which depicts the manner in which materials are linked to provide a structured hypertext environment for the instructor, class, and student.

This material is linked, concept to concept. This highly complex structure provides the users of the instructional system with a basic set of materials for immediate access. This material can be accessed in a read-only mode, or materials can be cut from here to be pasted elsewhere, or material can be added as necessary and linked to the existing data. What is not provided in this configuration is an entry point into the material. This is the tool which the instructor must derive based on the needs of the class and individual students. From this perspective, a class syllabus and an individualized remedial study plan are isomorphic. They both provide linked sets of entry points into the complex and highly structured hypertext document base. See Figure 3 "The Syllabus Provides Entry Points to Structured Hypertext" and Figure 4 "Constructed Remediation Links for Each Student".

These two diagrams show how the same document set can be used for two different purposes by taking advantage of the linked nature of the material. The syllabus is used to provide the student with a view of the entire course and the material related to it. Students receive an immediate indication of the material the instructor considers significant and an indication of the amount and complexity of the material used in the course.

As shown, constructed remediational materials may be highly elaborate and draw on all the course materials, or they may be quite simple when necessary and illustrate a single, narrowly focused idea. In either case, the ease with which the instructor can construct the package makes it much more feasible to develop a number of remediation packages at periodic intervals for each student. It is conceivable that intelligent processing could supplant the instructor in this process by analyzing student responses and tracking document access time by student to determine whether specific documents have been used in the study/performance process.

Students who access this material will need only travel the desired navigational links provided by the instructor. Instructors will find it a simple matter to build on-line, accessible remediational structures for individual students by the simple addition of linked data sets which reintroduce difficult material, reinforce previously discussed material, and assess the effectiveness of the remediation when it is complete. Students will not need to have the linkages made explicit, as long as they are aware of the nature of the material being delivered. This contextual information will, of course, be

significant in helping the student develop an understanding of the material which is available discussing this topic and the manner in which this material is related.

5. Conclusions

Hypertext is a young technology (Thronesbery & Rhoads 1990b). Nonetheless, it has potential applicability to many of the mundane information access problems which make training programs difficult to deal with and irritating to use. Unlike traditional database management programs which normally require the development of a prespecified data construct, hypertext systems are able to use data available in many different formats. This means that the instructional designer has the freedom to link many different kinds of information storage and presentation modes. A chapter in a book can be linked to a picture which can be linked to a table which can be linked to a journal article which can be linked to a graph. The hypertext developer does not worry about the form of the data, only the content.

This freedom also provides the instructional designer with the ability to develop useable classroom tools like the ones described in this paper: the syllabus builder and the remedial exercise construct. Hypertext document bases can be used to link large and varied amounts of information. Once built, that information can be tapped as a resource for students using on-line computer-assisted instruction. The tapping mechanism can be designed to accomodate group use (as in a class syllabus) or individual use (as in remedial exercises constructed for a single student).

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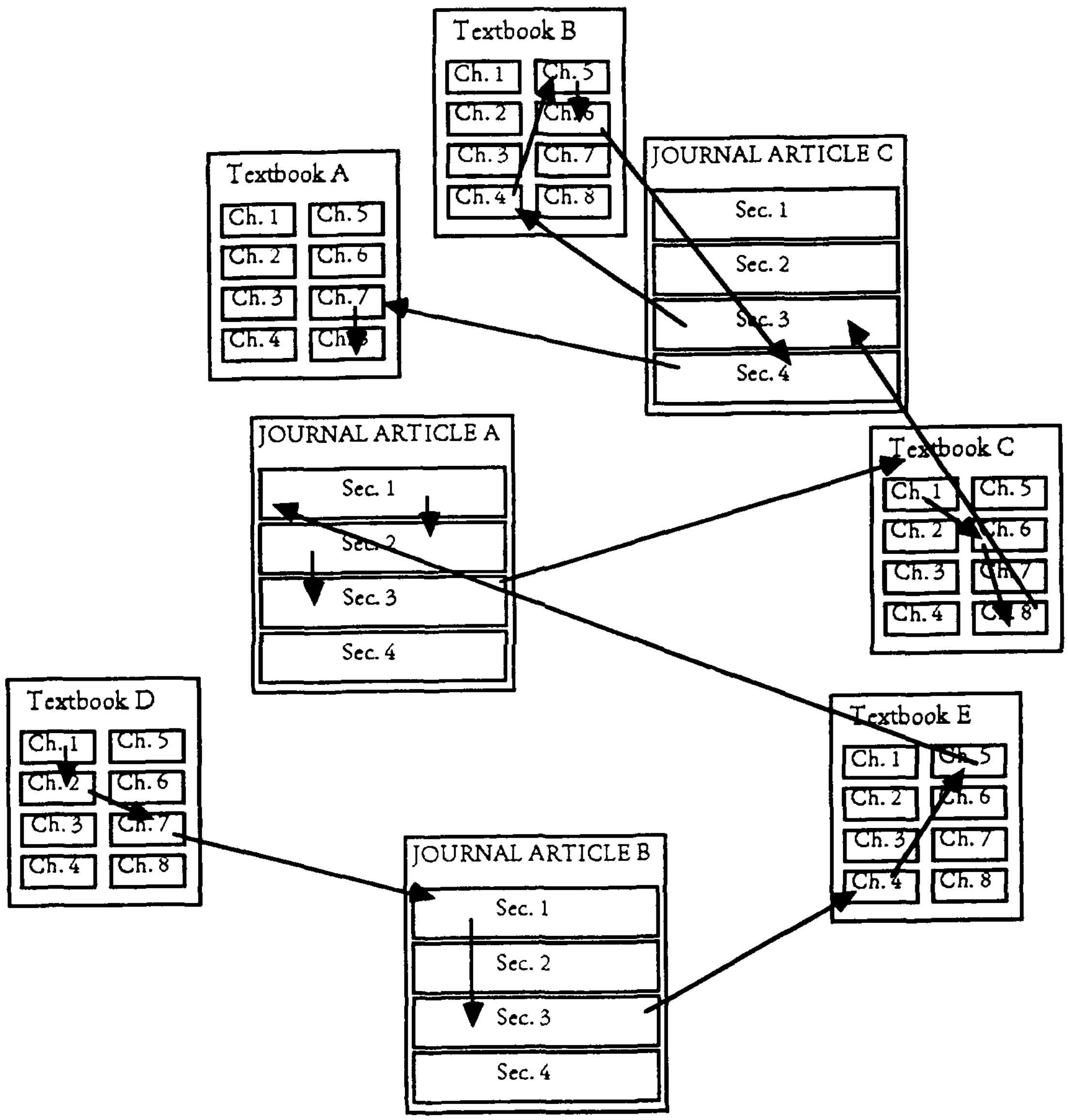

Figure 1. A Structured Hypertext Document Set

The Syllabus is:
Journal Article A - Sec 1, 2, 3
Journal Article B - Sec. 1, 3
Journal Article C - Sec. 3, 4
Textbook A - Ch. 7, 8
Textbook B - Ch. 4, 5, 6
Textbook C - Ch. 1, 6, 8
Textbook D - Ch.1, 2, 7
Textbook E - Ch. 4, 5

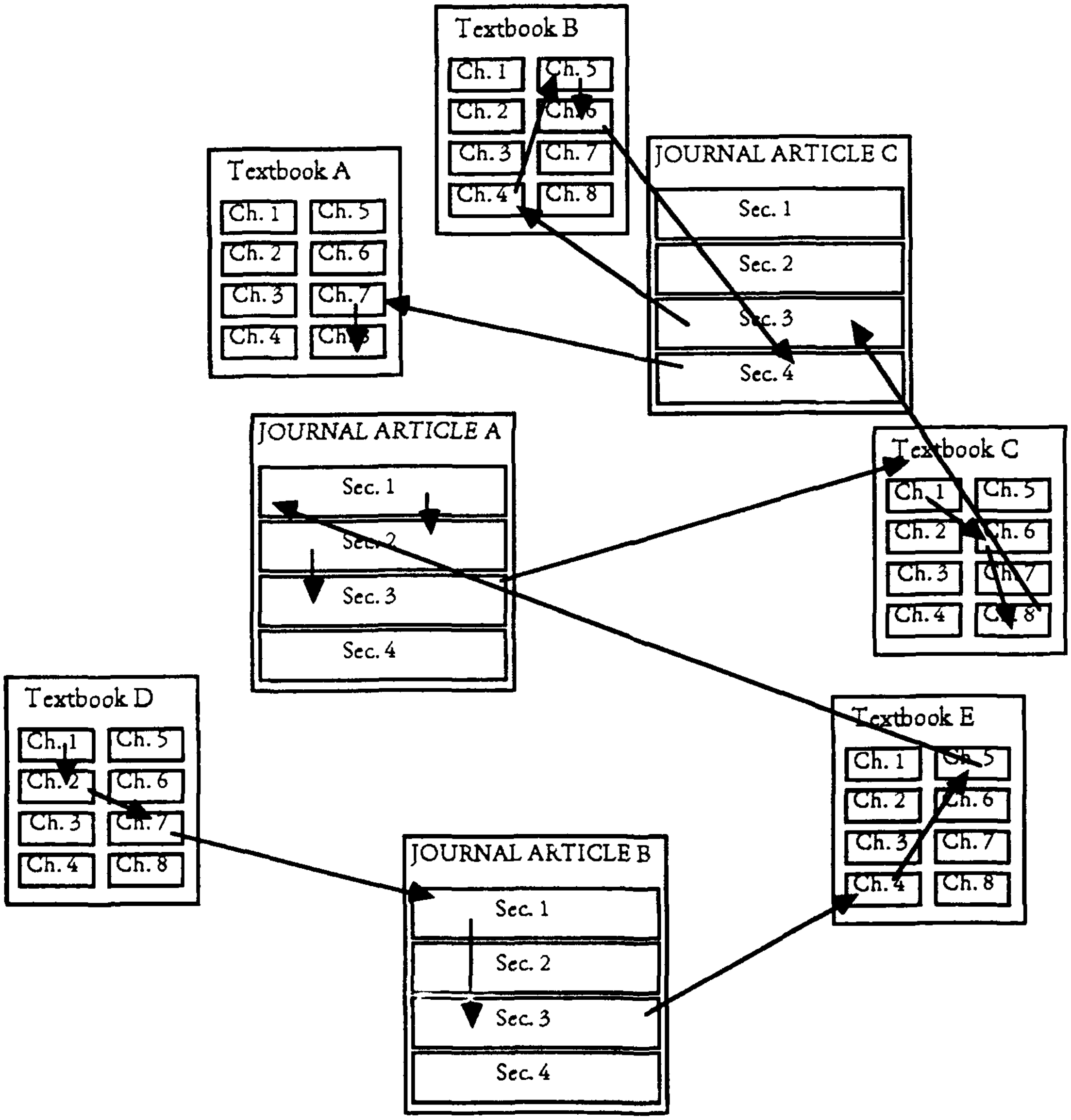

Figure 2. Using the Linked Information

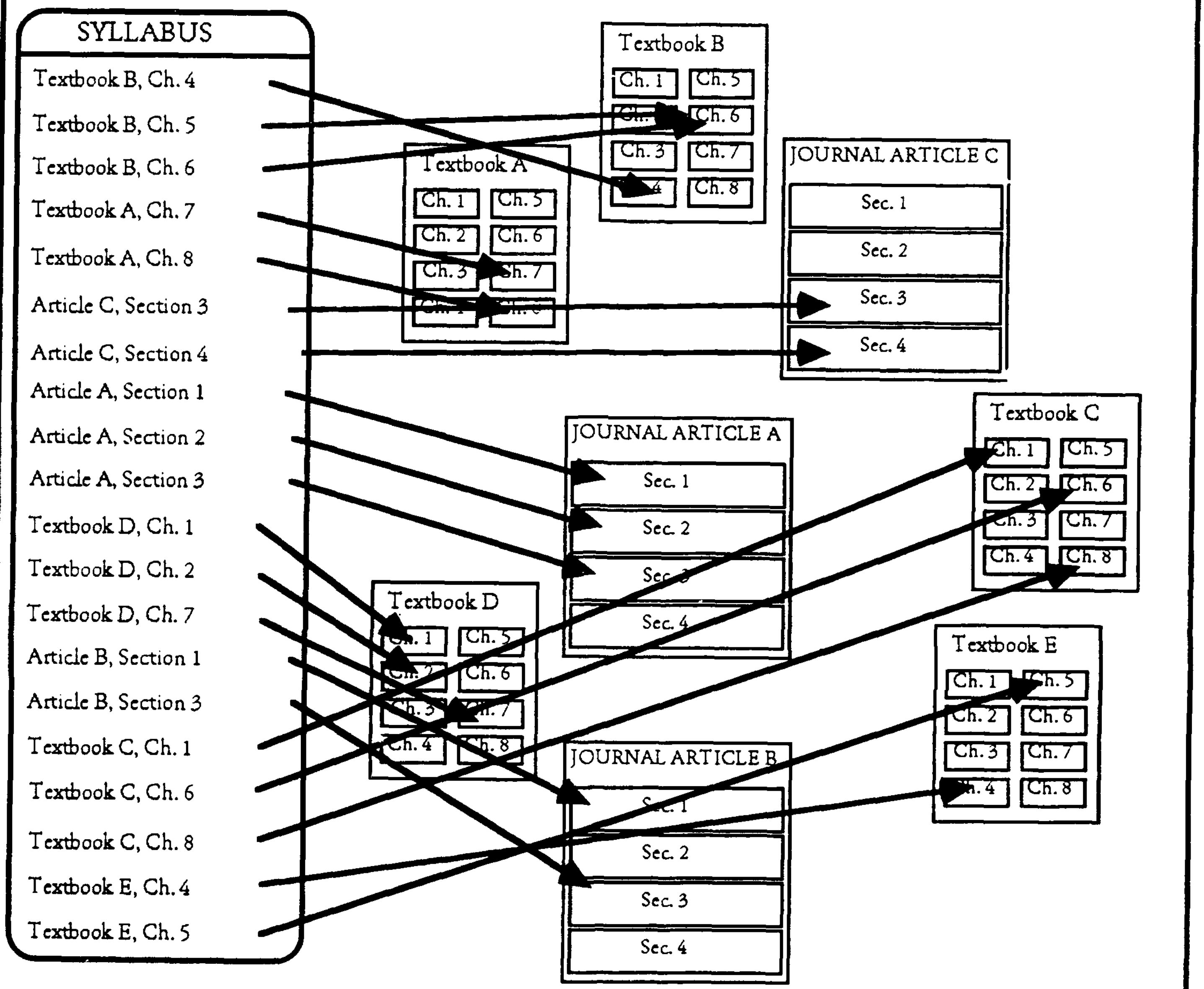

Figure 3. The Syllabus Provides Entry Points to Structured Hypertext

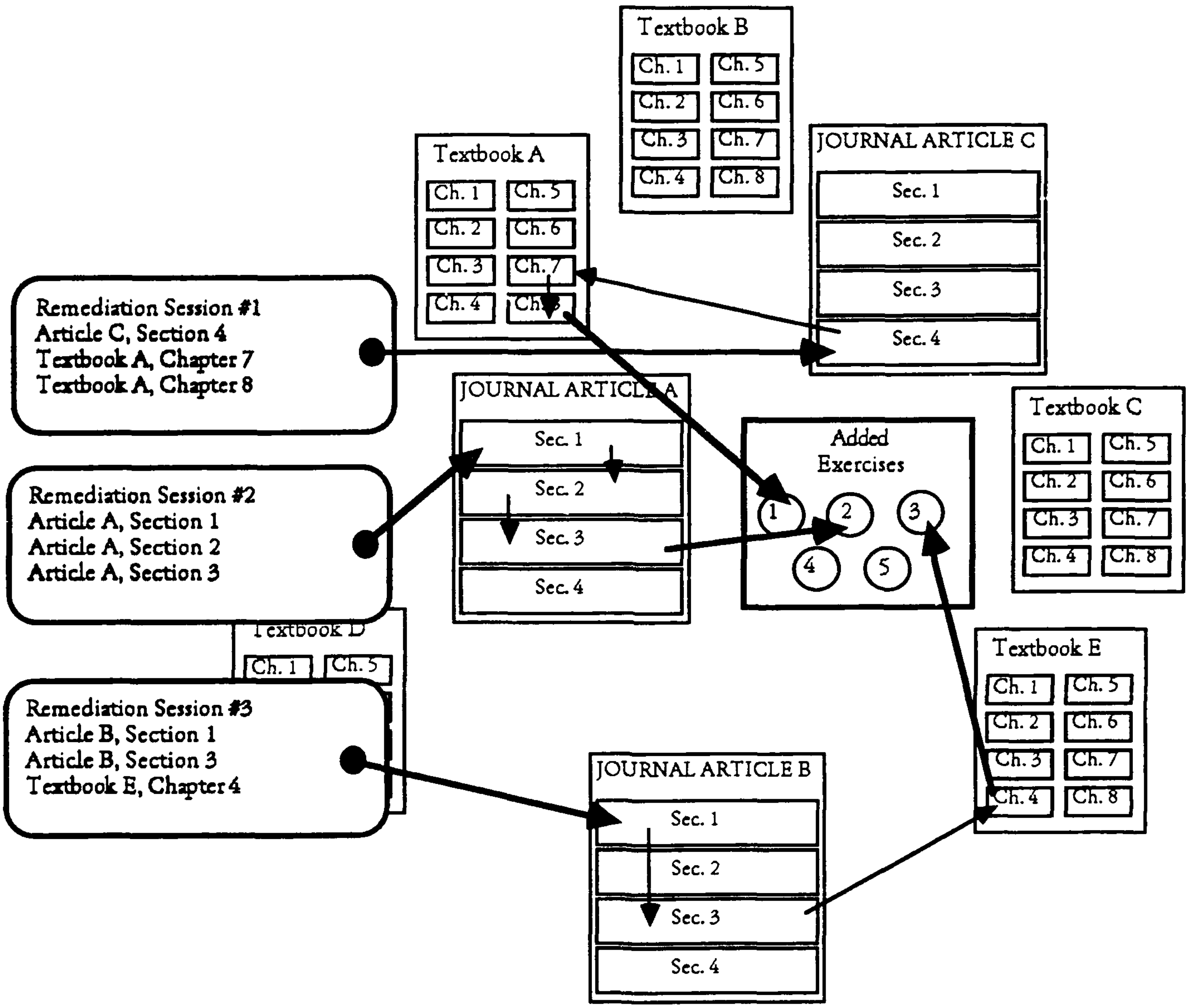

Figure 4. Constructed Remediation Links for Each Student

MANAGING CONTRACTOR DEVELOPMENT OF INTERACTIVE COURSEWARE (ICW)

T. Kent Thomas

As interactive courseware (ICW) becomes more widely recognized as a viable training media that can provide cost-effective training, more and more development is being done via contract. However, the process used to develop ICW is significantly different and more complex than that used to develop training for more traditional media such as platform instruction, written text, or audiovisual modules. As Gloria Gery states in her landmark book, *Making CBT Happen*, "As a training or project manager, you should know process is the key critical success factor. Manage it that way."

The author will present the ICW development process defined in the draft Military Handbook, *Manager's Guide for Development, Acquisition, and Management of Interactive Courseware for Military Training.* He will relate how deviations from that process can and have caused significant problems. The documentation developed during this process forms the major contract milestones and is the foundation of government quality assurance reviews.

The author will present lessons learned in five year's experience in managing six ICW contracts for development of over 50 courses. Successful contracting for ICW must begin with a clear definition of the process to be followed and the deliverables (both the documentation and courseware). Further, precisely estimating the scope of an ICW development effort is virtually impossible due to the number of variables involved. But, there are strategies that allow procurement of effective training within budget via firm, fixed priced contracts.

MR. THOMAS was formerly an Air Force Education and Training officer and a computer systems requirements analyst. With a B.A. from Carson-Newman College, he is now completing a Masters in Instructional Technology from Utah State University. From 1981-1985, he was a Training Systems Analyst at HQ ATC/TTX. He served as ATC focal point for student management functions in the Advanced Personnel Data System (APDS) and project officer for the Branch Level Training Management System (BLTMS), ATC's largest operational computer-managed instruction (CMI) system. During 1985-86, he served as Chief, Training Initiatives Branch at HQ TAC/LGQT, where he helped plan TAC's ICW initiative. He activated the 4400th Maintenance Training Flight (MTF), TAC's maintenance ICW development and management center, assuming command in 1986. The Tactical Air Forces (TAC, PACAF, USAFE, AFRes, and ANG) now have over 30 interactive videodisc (IVD) maintenance courses implemented throughout the world, operating on approximately 300 training systems. Over 30 more courses are in work, by both contractors and 4400 MTF personnel. The 4400 MTF has developed nine IVD courses internally, including the winners of the Nebraska Videodisc Design/Production Group's award for best government/military achievement in both 1990 and 1991. He is now the Director of Commercial Courseware Development at Allen Communications, Inc., Salt Lake City, Utah.

MANAGING CONTRACTOR DEVELOPMENT OF INTERACTIVE COURSEWARE (ICW)

T. Kent Thomas

Introduction. Contracting for the development of training materials can be a frustrating experience with disappointing results. These conditions are compounded when the complexity of interactive courseware (ICW) is added. Contracting for ICW development has traditionally been a risky venture, for both the contractor and the Government. There are all too many examples of cost overruns, defaults or judgments, and marginal products. Perhaps it is because there are so many diverse theories of instructional design that get translated into very subjective media treatments and presented to students by fairly complex computer software. Or, perhaps it is because no one truly knows how people learn. In any event, designing and developing effective ICW is often more of an art form than a scientific discipline. Just imagine trying to contract for the original design of a work of art - especially with a fully competitive, firm fixed-price contract! I sure wouldn't want to arbitrarily award the contract to the lowest bidder....

About five years ago I was contacted by an associate to see if I'd participate in a working group to develop a "generic" contracting package for ICW. I quickly concurred, since I was then involved with one ICW contract that clearly had some shortcomings and was defining another. I definitely could use the help and advice, even if I could contribute nothing but "lessons learned". Consequently, I had the privilege of being a "charter member" of the Joint Service Action Group (JSAG) to Develop Interactive Courseware (ICW) Data Item Descriptions (DIDs). DIDs are the contracting documents to define the format and content of any data (information, regardless of form or media) delivered via contract. This ad hoc group of ICW developers and end-users from all the services proved to be an excellent forum for sharing problem areas, prospective solutions, and lessons learned. Meeting quarterly, it has been a very productive organization, producing almost 20 standard ICW DIDs, a glossary of ICW terms, the revisions necessary to incorporate ICW in MIL-STD-1379, *Military Training Programs*, and most recently a draft (as of the date of this paper) Military Handbook, *Manager's Guide for Development, Acquisition and Management of Interactive Courseware for Military Training.*

Perhaps the most interesting aspect of participating in this JSAG was in discovering the commonality - everyone was encountering similar problems. We soon found that everyone meeting success was also following a similar design and development process, with similar design documents being delivered and reviewed. Corrective actions that solved a problem for one participant were often tried elsewhere, and quickly became common practice. This theme of practical, "real-world" validation was prevalent. Even the DIDs that we developed were "test driven" as "one-time DIDs" on ICW contracts before formal submission and approval for DoD-wide use. There is now a common, proven approach for defining and managing contractor development of ICW. I would NEVER state that this is the only ICW development process that works. But, I fully agree with Gloria Gery (1988) that the process used to develop ICW is the key critical success factor. When it is impossible to completely define the end product, as it is with ICW, you must define the process that will be used to produce, test, and evaluate it. So, the keys to success in contracting for ICW are in defining the end products required as clearly and concisely as possible, plus the process the contractor will follow to develop those products. The development process then becomes the foundation of the Government's quality assurance (QA) program to ensure the products meet the originally defined requirement. It is in the QA of deliverables that the Government is most actively involved.

This paper will briefly describe the ICW design and development process contained in the Military Handbook previously mentioned. Note that the handbook also contains guidance on front end analysis for ICW and maintenance of the ICW after development. Those topics will not be addressed. Similarly, this paper will address only key points, based on practical

experience, and is not an in-depth treatment of the subject. Refer to the referenced documents for more details. (I strongly recommend the Military Handbook to anyone involved in ICW development or management.) The focus of this paper is on key points, lessons learned, and specific tips of practical value.

Statement of Work. A clear, concise statement of work (SOW) is the foundation of the entire ICW development project and all management controls (both contractor and Government) since it establishes and defines all contractor efforts. For general guidelines on SOWs, see MIL-HDBK-245, *Preparation of Statement of Work*, and MIL-HDBK-248, *Acquisition Streamlining*. A Government sponsored survey of the ICW industry identified several factors that affect the contractor's ability to price an ICW design and development contract accurately (i.e. these factors increase the technical, cost, and schedule risks for both the contractor and the Government). Each factor could have, and should have, been addressed in the statement of work. Let's examine them in the order of their importance and potential impact.

Course Scope and Objectives.

Precisely estimating the scope of an ICW development effort is virtually impossible due to the number of variables involved. The length, complexity, subject matter and target audience impact the scope, just to name a few of the factors involved.This difficulty in defining the scope of ICW development efforts can increase the contractor's risk to the point that it is very difficult to use firm, fixed price contracts. This leaves the Government vulnerable to any unforeseen problems and the resultant prices increases. However, you can shift the risk associated with vague scope away from the contractor and to the Government, significantly decreasing the chance of problems. Lets look at one method of estimating the course length and complexity for a technical skill such as aircraft maintenance.

First, define the training objectives as clearly as possible, including enabling objectives. Then, estimate the time required to teach each objective to a single "average" student using one or more of the following traditional methods, including all tests or evaluations:classroom lecture and task demonstration; guided and then independent practice; hands-on performance testing with actual equipment. Use a panel of experienced instructors (minimum of three) familiar with the subject matter and target population to make these estimates, if possible. Try for a consensus on the estimated time. If you can't get a consensus then get them to establish a range of high, low and average times. The smaller the range the better.

Next, have the panel estimate the percentage of the total training time that each method is used for each objective. For example, consider a maintenance task that takes an estimated two hours to teach. Classroom lecture describing the task, its importance, and demonstrating how to perform it takes approximately 30% of the time. Student practice in performing the task, with initially full assistance then decreasing levels, takes 50% of the time.Evaluating the student's performance, hands-on, will take the remaining 20% of the time. This example yields 36 minutes of lecture and demonstration, 60 minutes of practice with decreasing levels of assistance, and 24 minutes of hands-on testing. Repeat this process for every training objective. Then add up the time each instructional method would be used in the entire course (i.e. all the objectives).

This process describes the content, course length, and the complexity of the course in traditional terms. Next, this must be "translated" to ICW. The JSAG defined three levels of ICW presentations that describe both its complexity and its interactivity, as follows:

LEVEL 1 - Baseline presentation. This is the lowest level of interactive courseware development. It is basically a knowledge or familiarization lesson, in linear format (one idea after another), used mainly for introducing an idea or concept. The trainee has little control of what is seen (minimum trainee interactivity). The two types of baseline presentation are: 1) Video and minor text presentation 2) Graphics and minor text presentation.

LEVEL 2 - Medium Simulation Presentation. This medium presentation level involves the recall of more information than a baseline Level

1 presentation and allows the trainee to have increased control over the lesson presentation (e.g., use of touch screen or lightpen to rotate switch). A moderate degree of simulation is used in the presentation.This presentation provides the following:

1) Combined information and skills lessons
2) Moderate degree of programming
3) Trainee interactivity with various I/O devices
4)CMI to track and analyze student performance
5) Normally combines video and graphics presentations.

LEVEL 3 - High Simulation Presentation. The highest level entails aspects of both Level 1 and Level 2 while using the fullest abilities of interactive courseware. Every possible subtask is analyzed and presented for full, on-screen interaction, similar to that used in aircraft simulator technology. The trainee can determine areas in which further training is desired. This presentation provides the following:

1) Primarily used for procedural tasks/skills
2) High student interactivity
3) Extensive branching capability (falls short of artificial intelligence)
4) Maximum remediation opportunity (e.g., multiple responses measure degree of error and give relevant responses)
5) Real time event simulation with minor equipment limitations (e.g., timing sequences of start-up, switch changes)
6) Capability to interface with other output devices
7) Exhaustive CMI capability.

These presentation levels correlate quite well to the traditional instructional methods used for estimating, above. Subjects taught by classroom lecture and demonstration can be presented by Level 1 ICW. Guided and independent practice methods can be presented by Level 2. Subjects evaluated by hands-on methods can be presented by Level 3. But, research strongly indicates that ICW achieves equivalent levels of student proficiency in significantly less time (Fletcher, 1990; DeBloois, 1984; ATCP 50-4). I'd recommend that you be somewhat conservative, until you've validated the efficiency of ICW in your training environment. So, initially reduce your estimates for each presentation level by no more than 20 percent, when converting estimated traditional training time to estimated ICW length.

Define the scope in the SOW by describing the target population, listing the training objectives, and defining the hours of ICW (based on the average student contact time at small group tryouts) to be developed for each presentation level. Include the JSAG definitions of presentation levels, since the ICW industry is becoming familiar with them. Include incremental options in the request for proposals to procure additional training that can be executed on or after award to take care any inaccuracies or underestimations.

I make no claims on the initial accuracy of the results provided by this method, also due to the number of variables involved. The accuracy of the panel's estimates is the prime one, and appears dependent on the number of instructors used to develop the estimates and their experience in teaching the same or similar subject matter. This approach merely adds structure to a subjective evaluation and judgment - i.e. it's a "soft process". Continue to refine and apply it and the accuracy of your estimates should improve. In our experience it works just as well as some much more elaborate estimating models and it is much easier to use and explain.

Predisposition to Media Features and Instructional Approaches. This second factor contributing to risk is essentially a strong preference on your part that should be clearly communicated to the contractor. Your preconceptions will directly influence how you view the contractor's work. The solution to this problem is to either require compliance with an ICW style guide that defines your preferences or have one developed that establishes the conventions or standards to be used. The style guide should, as a minimum, address these areas: sample course and lesson architecture, video and graphics screen composition, student interaction with the courseware, screen color schemes, menus, icons, testing strategies, and language conventions. Leave flexibility in instructional design, and focus on "ICW

operation, look and feel". But, do not compromise on basic principles of instructional design, media, learning theory, cognitive psychology, etc.

On our first ICW contract, we didn't have a style guide in the contract and didn't know we needed one - until the first courseware was under development! We had accepted the responsibility for quality assurance, acceptance testing, and configuration management (including updates after final delivery) of a previously awarded contract. The contract was the outgrowth of an independent research and development project as a technology demonstrator to assess the effectiveness of interactive videodisc (IVD). What we had accepted management responsibility for - more than a definitive product - was a process of producing ICW based on software and instructional design principles and practices. Basically, we could not "require" the contractor to do more than make sure the ICW complied with the course outline, flow diagrams, scripts, and storyboards that we approved at each stage during development. Even the requirements for these design documents were vague (the JSAG DIDs weren't available then).

The initial courses were a rehosting of the technology demonstrations (cockpit procedure simulations and the corresponding motion video demonstrations). With the contractor's full cooperation, we mutually defined how and then converted them to stand-alone exportable training packages. The quality of the courseware gradually improved as the contractor progressed to new courses and improvements continued over the term of the contract. This was partially due to the contractor's selective and voluntary compliance with a style guide that we developed as we went along. The contractor built templates, used them, and incorporated recommendations to make additions or enhancements to each course as timelines and budget allowed.

We accepted similar responsibilities on a second contract shortly after the first one. This was our first opportunity to provide input on an ICW SOW, so we required the joint development and approval of a style guide after contract award. We worked closely with the contractor to jointly develop a style guide based on research into the ICW literature, experience with other media, other available style guides, and limited hands-on experience from our in-house development efforts. There were several problems with this approach, even though the conventions were mutually agreed upon.

First, the style guide lacked detail in several important areas so it poorly defined our expectations. Second, the wording was not restrictive enough and was still open to too much interpretation. Third, it did not differentiate between essential items and those that are "nice to have". Finally, it was developed without our seeing prototype lessons based upon it. When we finally saw some of the interpretations in the first courseware, we didn't like them too well, but it was too late to change it on this firm, fixed price contract. We learned from our mistakes - and revised the style guide.

This revision more clearly defined our preferences, having seen things we didn't like. It also incorporated an ICW evaluation checklist to ensure reviewers focused their attention on what we considered the critical items. We provided it as government furnished information on the next contract. It communicated better but it still wasn't definitive enough - we had not clearly identified the mandatory items to the contractor. Further, we only stated in the SOW that the contractor would "develop ICW in accordance with the style guide." We couldn't enforce it, though there was more compliance than with the previous contract. At least we were communicating and the development process was working.

The fourth ICW contract (and third version of the style guide) worked better. We defined the guidance in the style guide as standards and conventions, with a "sliding scale" of restrictiveness. First, some items are absolutely mandatory standards and cannot be waived. Second, some items are considered standards but can be waived. Third, we defined items as conventions that will be followed unless there is a technical or instructional reason for noncompliance. The remaining items were considered informational and compliance was optional. We also changed the ICW evaluation checklist to reflect these levels of restriction for

items that were not optional. Our style guide had evolved into a document describing a common student interface, instructional and media design principles, a sample course structure, and the student data-gathering requirements. There was still considerable latitude for creativity in design - even the sample course structure was optional. Then we stated in the SOW that "the contractor-developed ICW shall reflect the design requirements of the attached style guide".

We required the contractor to perform an internal quality control review of each deliverable or document using the criteria identified in ICW evaluation checklist from the style guide. We also stated that "the contractor shall comply with the guidelines specified in the style guide, or request a waiver in writing through the contracting officer to the Air Force user organization, including supporting rationale and any recommendations for improving or changing the requirements of the style guide." We also provided sample courses as Government furnished information to illustrate the style guide requirements. It's communicating pretty well - we even used this version of the style guide on *another contract* without revising it!

We strongly recommend that you provide a style guide as an attachment to the SOW and require the contractor to comply with it or request written waivers. If you do not have a style guide, then request copies from others - since they've been developed by several different organizations. I have never been refused when I requested a copy of a style guide from another military organization. We provide ours freely and they respond in kind. Either use the best one you can find, create your own using the best from each one, or pay the contractor to develop one prior to actually beginning courseware development. If possible, provide ICW samples that illustrate your preferences. If you cannot, then require the contractor to develop a prototype lesson that incorporates these guidelines, also prior to actual courseware development. This will show their interpretation of those guidelines and you can then revise them as necessary, as long as the contractor agrees. In our experience, style guides are essential. If you do not provide one, the contractor must either use their own or develop one.The contractors prefer that you tell them what you want "up-front", since they don't enjoy surprises either! Meanwhile, our style guide is under revision again, incorporating more lessons learned about ICW instructional design, development and contract management....

Availability and Stability of Government Systems, Equipment, and Personnel. This is one risk-contributing factor that you may have little control of, in some cases. It involves two closely related aspects, including reasonable contractor access to Government bases, systems, equipment, technical data, and subject matter experts (SMEs).But, no less important is the stability of those resources. Is the configuration and operational capability of the systems and equipment changing frequently? Will the same SMEs or other key personnel be available throughout the entire project? Where?

The stability of weapons systems, support equipment and technical data has been a constant problem for us. Since a large part of our ICW is to support "differences training" and conversion to new weapons systems, they are constantly changing. Our first contract didn't address the issue at all. However, since it was the prime contractor that was also developing the courseware, they often knew of forthcoming changes before we did, and changed their development plan accordingly. There were still some "surprises" but the contractor voluntarily incorporated the changes into the courseware - but not the documentation in all cases.

The second contract, also with a prime contractor. still did not adequately address these issues (we hadn't been "bitten" on the first contract at that point). It merely required the ICW to agree with the previously reviewed and approved design documents. However, we were able to get tech data changes incorporated in the design documents during the development process in some cases. For example, a tech data change after the flow diagrams were approved was incorporated in the scripts and storyboards - (and consequently in the ICW) but the flow diagrams were never completely updated. They were annotated during red-line reviews, but new ones were never produced incorporating the edits.

The largest problem on this contract was that the aircraft was late coming off the assembly line, as was some support equipment and all the tech data. Luckily, since it was the prime contractor the Government was not liable for damages or cost overruns for failure to provide aircraft and tech data to the contractor at the scheduled times. We couldn't readily provide them with something yet to be delivered to us. We were required to provide access once the aircraft were delivered, and we did. On the last delivery increment, we received large tech data changes after small group tryouts and prior to final acceptance. The contractor did not incorporate the changes. As it was, the contractor probably lost money on this ICW contract due to schedule slippage. Impact to the government, in addition to the ICW being delivered late, was that the last increment needed updates as soon as it was delivered. The Government awarded the ICW contract to the prime contractor in order to make the ICW contractor share some of the risk. In this case both parties paid! Such is the nature of ICW development for a brand new weapons system! But, no other maintenance training devices were available that simulated the aircraft. The only alternative to ICW was to dedicate more actual aircraft for use as training devices.

The third contract, also to a prime contractor, required the contractor to develop an incremental delivery schedule based on the availability of validated technical data and efficient utilization of his resources. It also required the courseware to be technically correct at small group tryouts. Up to that point the contractor had to incorporate all technical data changes. The Government was vulnerable to tech data changes only after tryouts. But, we didn't require the contractor to go back and update the documentation. Instead, they had to correct all errors that we identified during reviews and submit a corrected copy within 30 days. So, even though the ICW has been current upon delivery (to this point we have not had a tech data change during the interim between tryouts and final delivery), the design documents have been current only in some cases.

The fourth and subsequent contracts require that both the ICW and the design documentation be current at small group tryouts. This may appear to place undue risk on the contractors. However, we use prime contractors for emerging weapons systems, where both the delivery schedule and course content are the most dynamic. We use competitive contracts for older, less dynamic weapons systems. We also require the contractor to perform a brief front-end analysis to refine and revalidate the requirements, and to make any recommendations for changes in course content. Then, the contractor would propose an incremental delivery schedule based upon the availability of validated technical data and efficient utilization of his resources. In a nutshell, we pay the contractor to examine the potential for changes and to develop a schedule that will try to avoid the problem areas. We are also supportive of changing the sequence that specific courses will be delivered, to coincide with availability and stability of all required resources (including tech data).

We insist that the ICW be technically current at small group tryouts. We've found that you are essentially wasting your time in performing small group tryouts on an "out of date" course for several reasons. First, the students are very sensitive to "face validity" - - if the ICW isn't accurate and current, they "tune out" immediately, invalidating the results. Second, it is more difficult to objectively evaluate the ICW against a previous, "frozen" baseline that no longer exists in the "real world" than if the ICW is current. For example, if there a need to resolve a question about how a piece of equipment actually operates, you and the contractor can mutually observe it in operation. How could this be done when the operation of the equipment had changed but the design of the ICW had not? Further, if any substantial changes are required to make the ICW current - which it must be prior to implementation - then it may need to go to small group tryouts again. Why do it twice unless absolutely necessary? Finally, it encourages the contractor to develop ICW that is easily updated, should changes occur. Some ICW design techniques can significantly impact the ease of updates. For example, video still-frame equipment simulations can easily be updated with authoring changes, if the needed video exists. This encourages the contractor to develop visual databases in case of changes. These databases greatly reduce ICW configuration management

and update problems during development and after acceptance by the Government.

Subject matter experts (SMEs) are also a critical part of the ICW design and development process, both in "quality and quantity." They should have the highest and most current technical qualifications available, work well with others, and have good communications skills. If at all possible, they should have enough projected tenure to complete the project. A change in SMEs during the design and development can have a significant disruptive effect on the effort, as the new SME tries to learn everything that took place before. They will likely want to make changes, so expect it. Do not allow them to change the design unless both you and the contractor agree. Should they find technical inaccuracies, those should be corrected, of course.

Sufficient contractor access to SMEs is also critical factor, though the degree may vary based upon the course content. Be sure to clearly specify the SME support that you can provide in the statement of work, and be prepared to discuss it with the contractor(s). I guarantee that it is a sensitive issue if the contractor is developing completely new training materials. It has been a "bone of contention" at some time on every ICW contract I've ever been involved with. There are no specific guidelines that I can give on "how much is enough." In general, give as much SME support as you can afford, but monitor how the contractor utilizes the SMEs and make sure that the time is productive.

Note that if any Government reviewer changes, not just the SMEs, it can have a disruptive effect on the contract. This reinforces the need for specified guidelines, such as a style guide. Guidelines greatly reduce the subjectivity in product evaluation for everyone concerned.

Review and Approval Processes. The review and approval process should be defined in the SOW and based on the deliverables from an iterative ICW design process. The ICW should be designed in stages of increasingly greater detail, with review and approval by the Government prior to the contractor proceeding to the next stage. Similarly, the delivery of the final ICW should be in increments (units, modules, courses, etc), if at all possible. This allows "lessons learned" by both the contractor and the Government to be incorporated in the next incremental delivery. Do not assume that it is either more efficient or effective to "review it all at one time." One ICW contract I'm aware of did not require either of these processes. The contractor was allowed to proceed from approved lesson design outlines to delivery of all the ICW at one small group tryout without a formal Government review of any further design documents. The Government representatives were not aware of any serious problems until the contractor failed to meet the ICW delivery date (for a multitude of problems including availability of SMEs and equipment). The contractor eventually made it to small group tryouts over a year late, only for the Government to cancel the tryouts the first morning because the ICW was totally unacceptable. As of the date of this paper, the ICW still has not been accepted, though it made it through tryouts. It is still being revised - as it approaches being two years behind schedule - and the Government has acknowledged it will likely be of marginal quality.

The ICW design and development process defined in the cited Military Handbook makes use of the JSAG's original efforts in defining standard ICW DIDs. However, the JSAG was later tasked by the Office of the Assistant Secretary of Defense, Force Management and Personnel (OASD/FM&P) to incorporate the ICW and the DIDs in MIL-STD-1379, *Military Training Programs*, while it was being revised. This incorporation revised the DIDs and merged them with other new training development DIDs where appropriate. The Military Handbook includes only these new DIDs, though the intent and purpose are the same as the originals. Appendix B of the Military Handbook describes how to invoke, tailor and use these revised DIDs. The new DIDs are listed in parentheses after the appropriate descriptions below. The titles of the original DIDs are used in this discussion since they are more descriptive of the content and purpose.

The DIDs that we have used consistently are listed below in the general sequence that they should be developed, delivered and reviewed. Note that there are other DIDs available. Your contracting office or data item manager can

provide further assistance in selecting and tailoring DIDs. Also note that you should thoroughly review any of these DIDs to delete any requirement for information that you do not need. They contain several requirements that are unique to the particular military services and any unnecessary information will increase the cost for no purpose.

ICW Contract Work Plan, DI-MGMT-80549, provides a detailed description of management tasks which must be completed to fulfill guidelines for development of ICW. It describes the management structure, milestones, lessons to be developed, travel schedules, personnel and organization, validation process/criteria, and quality control activities. (DI-ILSS-81070, *Training Program Development and Management Plan*)

ICW Design Strategy, DI-ILSS-80547, describes the general design, structure, content, instructional strategy, and media treatment of the ICW. (DI-ILSS-81091, *Instructional Media Design Report*)

ICW Flow Diagrams, DI-ILSS-80548, provide a detailed map of the intended logic of the subject courseware. They include all defined lesson tasks, information frame or sequence, decision points, branching options, and remediation. (DI-ILSS-81091, *Instructional Media Design Report*)

ICW Video Shot Support Plan, DI-ILSS-80802, describes all resources (personnel, equipment, facilities, etc.) required for support plus all needed information to plan and coordinate ICW video production, to include dates and durations. (DI-ILSS-81091, *Instructional Media Design Report*)

ICW Script-Storyboards, DI-ILSS-80546, provide a blueprint for the production of the ICW. Includes scripting information and visual representations of the materials, plus all required directions for the video director, programmer and instructional designer. (DI-ILSS-81092, *Instructional Media Package*)

ICW Video Shot List, DI-ILSS-80803, describes all video shots required to produce the ICW, sorted in a sequence to minimize camera setups.(DI-ILSS-81092, *Instructional Media Package*)

ICW Edit Decision List, DI-ILSS-80804, describes the planned video editing by specifying start and end points of resource video and audio in the sequence they will be assembled. (DI-ILSS-81092, *Instructional Media Package*)

ICW Terminology Document, DI-ILSS-80550, lists all abbreviations, acronyms, mnemonics, etc. used in naming or describing modules, lessons, data files, subroutines, screen displays and variables in the ICW.(DI-ILSS-81092, *Instructional Media Package*)

ICW Manager's Guide, DI-ILSS-80552, briefly describes the content and structure of the ICW, how to install and operate it, and how to produce student management reports. (DI-ILSS-81096, *Training System Utilization Handbook*)

The design strategy, flow diagrams and script-storyboards are the most important and most used documents, since they define the actual course content. Require that they are developed for each incremental delivery of ICW and delivered in sequence. Each one must be reviewed and approved before the contractor proceeds to developing the next one. Do not formally accept the documents when initially submitted, merely approve them and give the contractor authority to proceed. Note that if you formally accept the document then you have just baselined the design of the course and the contractor cannot be required to make any significant change in the course design. These documents should be thoroughly reviewed by both instructional designers and subject matter experts when initially received, generating discrepancies that must be corrected and any recommendations for improvement. If the course will simulate a piece of equipment, process, or procedure, I strongly recommend that you (and the contractor, if possible) "walk through" the flow diagrams "live" with the applicable equipment, process or procedure to verify the accuracy of the simulation logic involved prior to approving the document. If the simulation is either very detailed or very complicated, consider "walking through" the storyboards also.

These documents should remain in draft until after small group tryouts of the courseware, and available for review at every interim review point. This allows the iterative instructional design process to further refine the instructional strategy as necessary while making sure there are no significant changes in course content. Do not require the flow diagrams to exactly match the initial design strategy, for example. Allow the contractor to make changes in the instructional design as necessary as the next stage is developed - as long as you review and approve the change and all preceding documents are updated. If you "force" the contractor to follow the previously approved design documents verbatim, you limit their creativity and the quality of the final product. On the other hand, do not allow them to make changes just "because they wanted to." Require that they explain how the change in the instructional design will improve the ICW. This will also help you conceptualize and understand their "view" of the ICW. Do not allow them to make a significant reduction in the scope of the delivery increment, as defined in the SOW by objectives, estimated length, and presentation levels. That is, unless you agree that it is appropriate and the contractor offers "tradeoffs" such as increasing the number of optional practice exercises in the ICW or increasing the next increment.Make sure you document any reductions in scope on a given increment, and that the contracting officer is aware of and agrees with the change (or has delegated authority to you).

The video shot support plan, video shot list, and edit decision list are used only when required, such as for interactive videodisc. They should also be developed for each delivery increment. They should be submitted and revised only as necessary for acceptance. They should not remain in draft, since they are "one-time" requirements. The shot support plan is usually produced after the flow diagrams, while the script-storyboards are being developed, to tell you what they plan for the production. This allows you the lead time to coordinate all support and have it ready when needed. The shot list is to ensure the video production is both complete and efficient. It should be comprehensive (i.e. listing every required shot), sorted to minimize camera setups, and cross-referenced to the script-storyboards. It should be reviewed and accepted prior to the first day of scheduled video production. The edit decision list is to ensure the on-line edit session is well-planned and efficient, and to allow you the opportunity to review the video footage that will be assembled (if you desire), prior to it being edited. It should be reviewed and accepted prior to the first day of scheduled editing.

The next stage is authoring, where the actual ICW is assembled, incorporating all graphics screens and video, to include all branching logic. The actual courseware should be reviewed at least twice. The first review (alpha test or individual tryouts) should be done to ensure the ICW agrees with the approved script-storyboards and flow diagrams, it operates correctly, it is complete and ready for small group tryouts. You should also have it reviewed by a SME (preferably one involved with previous reviews) to verify technical accuracy. You should have two other documents delivered in draft at this point, as required. The terminology document completes the course design documents, and is very valuable when updates are required. It should be developed for each delivery increment. The manager's guide is the overall documentation on how to use and manage the ICW. If all the ICW will be incorporated into one course, require the manager's guide to be initially submitted with the first incremental delivery, and revised with each subsequent one. If the delivery increments are "stand-alone" modules or courses, require a complete manager's guide for each. If there are significant numbers of discrepancies at this preliminary ICW review, you should consider another review to ensure their correction prior to small group tryouts.

The second review (beta test or small-group tryouts) is similar to that for any other training package or media. Use your normal criteria for selecting the target audience and validating the results. However, the contractor should be present to observe the ICW in operation so he can understand any problems that may appear. As mentioned previously, validation criteria should be stated in either the SOW or the contract work plan. If the ICW validates in accordance with the stated criteria, then acceptance is a matter of the contractor

correcting any discrepancies documented at small group tryouts, and your verification of their correction. However, you should place a clause in the statement of work that "the Government reserves the right to repeat all steps of the ICW design and development process until assured that the ICW meets the specified and approved technical and instructional requirements." This "closes the loop" on the formative evaluation process and requires the contractor to make any changes necessary until the ICW validates successfully.

Factors Outside the Statement of Work. There are two other factors that impact the overall success of the ICW development effort. They are not a part of the actual statement of work, but should be incorporated in the contract. The first is the type of contract and the second is the payment schedule.

Due to the difficulty in specifically defining ICW contracts in the past, there were many types of contracts used. Each has its advantages and disadvantages. The ICW Military Handbook has an excellent discussion of the alternatives. In general, the most desirable type of ICW contract and the type with the least risk to the government is a firm, fixed-price contract. This type of contract pays the contractor a fixed price for the development of the product, regardless of the effort expended. Their efficiency is "rewarded" by increased profits, while they bear full risk for inefficiencies. It has been difficult in the past to award firm, fixed-price contracts because it was difficult for both the Government and the contractor to estimate the scope of the effort and the corresponding price. However, the use of this common ICW development process, standardized DIDs and definition of ICW presentation levels has changed that.

There are definite trends in the number of contractor labor hours being bid for ICW design and development. In our experience, and collaborated by other JSAG members, you can expect to see the following ranges of development hours per student contact hour (average at small group tryouts) for interactive videodisc ICW: Level 1, 200-250 labor hours/ICW hour; Level 2, 400-450; Level 3, 600-650. Though we have no direct experience, the reported ratios for ICW using computer graphics and no audio are: Level 1, 100-150; Level 2, 250-300: Level 3, 400-450. Note that these development ratios are decreasing as the industry gains more experience in ICW development and contracting for it. Technology is always producing more refined tools for ICW development also. Note also that the labor for Level 3 ICW is directly related to the complexity of the equipment being simulated and the amount of "free play" provided. For example, a "total free play" cockpit simulation of a new, complex fighter aircraft could exceed 2000 hours of labor per contact hour. Be sure to also define equipment being simulated and the amount of free play required as accurately as possible in the SOW, if dealing with complex equipment.

The second factor not in the statemet of work is the payment schedule. You do not want to pay too much money too early in the ICW design and development process to "protect yourself" in case of contractor problems or default. On the other hand, if the contractor must obtain loans to meet their payroll, these costs will be passed on to the government. A "partial payment" schedule, in which the contractor is paid a specified percentage at specific milestones works well to keep the contractor "motivated to perform." These milestones must be based on delivery and Government acceptance or approval of products - do NOT simply pay the contractor at specified periods of time. You must also balance the "partial payments" against the contractor's labor expenditures when deciding on a payment schedule.

We've had very good experiences with a partial payment schedule for each delivery increment, and with each delivery increment being separately priced. For example, a contract for five courses would pay roughly one-fifth the total contract price for each course. Upon Government approval of the design strategy for a given course, the contractor would receive 25% of the total for that course. Upon government approval of the script-storyboards the contractor receives the next 25%, with the remainder (50%) paid upon final Government acceptance of the course and all the supporting documentation. This approach pays the contractor frequently and steadily - as long as he delivers acceptable products.It also spreads

both the technical and financial risk across the duration of the contract. At any given time both the amount of money and product at risk is relatively small, should a major problem occur.

Conclusion. While managing the development of ICW is always a challenge, it can be done successfully. The keys to success are a clear and concise definition of what you want and a systematic process of development, review and approval. These factors should be addressed in the statement of work for the contract. The type of contract and the payment schedule can also reduce the rist to the government.

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Video-based Training Analysis and Rapid Prototyping of CBT

William F. Jorgensen, William R. Terrell, Cecil L. Wakelin

Current training demands have greatly increased the requirement for interactive technologies for development and presentation of courseware. However, data requirements for interactive training technologies are not supported by traditional Instructional Systems Development (ISD) techniques. Traditional ISD methodologies for identification of training requirements typically produce linear text descriptions of job, tasks, and task elements and do not describe the complex interactions of total performance within the environmental context of a job. Interactive training technologies have advanced training capability to a level that extremely complex training events and environments are possible. The linear text-based approach results in continuous re-visits to the job to collect data for IVD or other interactive/pictorial media, adding to the cost and resource requirements of the development process. Instructional design methodologies must advance at a pace commensurate with instructional technology. This advance must include the structuring of data bases capable of handling extremely complex task performance and environmental interactions. These data bases should include audio and pictorial, as well as linear text oriented data. An analysis technology is needed which is capable of prescribing detailed requirements for the interactive pictorial-based courseware.

This paper will describe the development of a video/audio data base structured to handle complex task performance and environmental information. It will also describe an analysis process that is capable of quickly prototyping audio video-based courseware and converting data into specifications for the development of learning objectives, instructional events, media, media formats, and specifying training systems features.

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Video-based Training Analysis and Rapid Prototyping of CBT

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State-of-the-art technology has had tremendous impact on the job environment. Pilots, operators, and other performers are faced with more threats, more information, more capabilities, and the need to make decisions at a much more rapid pace than ever before. Training individuals to cope with this much more complex job environment is pushing instructional technology to keep pace. Computer based training (CBT) has moved toward increased student interactivity with complex instructional environments. The technology that has so drastically changed the work and training environments also provides the technological capability so instructional design can keep pace. (See Figure 1) Computer-based technology and training analysts have been intermingling for years, and use of computers to analyze or develop is not new to instructional designers and training analysts. There have been many attempts and some successes using computers to analyze job/task data. (See Figure 2) A partial list includes TASCS, CASDAT, CASAT, ETRAN, ETASC, NOTADS, CATIDS, and more. The latest, and most promising traditional ISD automated process, is the Joint Service ISD/LSAR Decision Support System. (See Figure 3) None of these systems, however, directly support the development of state-of-the-art interactive instruction. Each system is based on analysis methodologies which produce linear text descriptions of job/task data appropriate to text-based courseware, media, and training materials.

<u>Requirements for video/audio data</u>

Traditional instructional design methodologies favor the use of text based presentation of each individual element of the job environment. When pictorially based courseware is required for training, and a linear text-based data analysis has been done, a re-analysis for more data is required to provide the courseware screens, pictures, and descriptions of the job interactivity. If we take a look at a typical CBT design process, such as this one for IVD (see Figure 4), we notice numerous revision loops. These loops represent several activities in an interactive design and development process. These loops also represent a backwards chaining process to the data collection procedure, representing costly re-analysis activity to collect more pictorial-based data from the job/task environment.

Interactive instructional technology is based on the fundamental principle that the student should interact with the job environment which is represented or simulated in the instructional environment. Job and task data collection must capture the total job environment including the interactions among the elements, the core of which is visual with verbal support information. Imagine, if you will, complex job environments such as an airplane cockpit (Figure 5) or a combat information center. Operators in these environments have multiple displays, multiple response choices, and are orchestrating a host of

concurrent events. Add a variety of intelligent and environmental external threats, plus the requirement to interact with other team members, and you have an idea of the complexity of the job environment. Traditional instructional design methodologies would examine each job and each task required to perform that job. The training analysis focuses on training the student to perform each discrete task, but leaves to the trainer the job of teaching the composite or concurrency of the tasks. To paraphrase a point Dr. M. David Merrill made in a presentation at the last TITE conference, (see Figure 6) there is something wrong when we propose to use technology to enhance and improve instruction, but advocate up to several hundred times more effort to develop the new technology based instruction. His point, of course, is to use the technology to improve analysis and reduce design and production time, as well as improve the instructional process. Dr. Merrill is, of course, attempting to do something about the courseware development process with his ID Expert 2.0. However, Merrill and Li state that "most of the content information required by a transaction is available directly from the content structure elaborated during content analysis process." Current technology also provides the tools for total content and instructional designers to collect data on the complexity of the job environment and then analyze that data to define those features of an instructional environment required to interactively train the job.

State-of-the-art instructional designers are conducting research and developing interactive audio video technology which can collect and organize job and task data, analyze the data, and specify the training system required. The focus of this paper is such a process which collects and analyzes complex job and task data. (Figure 7) The specific methodology described involves the use of video recording technology to create a video/audio data base. The use of automated coding procedures to describe basic cue, cognition, and response activity makes it possible for decision algorithms to analyze the data.

Using video data

Several companies and organizations have been using video as a data collection process since the inception of the portable video camera. Most of this work has been focused on workload or human factors analysis, and most of it has been collected in a laboratory or simulator setting. One such example, is the data collection at the SIMNET D facility, Ft. Knox, Kentucky. The purpose of the SIMNET video cameras is to observe and evaluate the activity of students using the SIMNET M-1 tank simulators from a remote observer station. The video tracks are observed in real time, and can be reviewed later to provide feedback to students. Dynamics Research Corporation (DRC) has been using the video data collected during simulator operation to examine operator workload.

Workload analysis procedures select a video data stream from the observer's video recordings, identify start and stop events in a task, replay the video, and observe and record the operator activity. (See Figure 8) The

recorded information is analyzed for workload determination. DRC is using the recorded video streams of data to examine the workload of the operator under various conditions, such as when the operators are using experimental or prototype equipment. An example is when new control panels are installed which change the tank driver's or commander's procedures.The video recording concept is the baseline for video based job/task analysis.

Developing the video audio data base

DRC is currently building a prototype data collection and analysis procedure for use by the Naval Training Systems Center (NTSC) for the specification of training system features. Development of this procedure consists of creating a data base which includes video and sound tracks (see Figure 9), and the creation of codes to label the activities recorded on the videotape and sound tracks. Algorithms are developed which analyze the codes. A reporting format specifies the required training device features. The data coding step is comprised of two basic elements: (see Figure 10) a pre-analysis to collect job data structure and data collection and coding. Development of a job data structure establishes the following (see Figure 11):

- What is the system?
- What are the appropriate subsystems, components, and other system definers?
- What is the function performed by the person-machine interface to be analyzed?
- What is part of and what is external to the operational and the person-machine environment?

For example, the system may be a fighter aircraft, the subsystem may be an air search radar, and the components may include a multi-function display control panel and a cursor control on the aircraft control stick (see Figure 12). The environment description may include the number of people in a cockpit, a description of cues to be expected both internal and external to the cockpit, the communication requirements, and the operational parameters or interfaces of the radar to other subsystems.

Development of a job data structure establishes the guidelines and boundaries for the analysis. For example, specifying which cues are influenced by the pilot, and which are not. This becomes important in the data collection and analysis process described next, because cues which are external to the operational environment of the pilot-machine interface are used to define segments of behavior.

Data to be collected (see Figure 13a) includes a video recording of behavior, including close-ups of controls and indicators. If audio is part of the job, this will be collected as well. This may mean two or more video/audio tracks. To collect this data, microcameras linked via fiber optics to recorders, will record the pre-determined data. Audio is recorded and synchronized with the video data.

Once the data is collected, the operator who performed the task adds a crucial aspect to the data base, the cognitive, e.g., decision-making, data. (See Figure 13b) To gather this information, the recorded

audiovisual job/task information is replayed, using a dedicated audio track, the operator narrates his or her reasons for doing things, what they were thinking while doing them, the sequence of the events and reason for it, what they are doing concurrently, and a host of other pre-determined data. This recording process uses a start/stop control during the audio recording, which allows the operator to stop the video/audio data stream if the cognitive description stretches beyond the physical time limit or length of the recorded video data. The cognitive track is produced by interaction of the operator with a trained analyst, who is cognizant of the needed information for each segment of the audiovisual data stream. Data also includes any still pictures, graphics, or text which will support the video/audio data base (see Figure 13c).

Use of the video/audio data base

A set of cue, cognition, and response codes were developed from review of research performed in the fields of psychology, human factors, and educational technology. Codes were selected which represented specific types of behavior and conditions in each domain (see Figure 14). For example, a visual cue on a radar screen may be Vg for videographic, B3 would represent Bloom's third level of cognition, and S3-PBM would represent Simpson's taxonomic rating of psychomotor activity at level 3 and involve the use of a push button multi-function display. The codes are assigned by an analyst when playing back the video and sound tracks using real time, slow motion, and stop action as appropriate. The codes are keyed to the video for retrieval, review, or other manipulations. To analyze the codes, algorithms have to be developed which compare, contrast, weight, match, or in some way make decisions relative to the code content and the combined meanings, depending on the products required. The data codes can be rapidly scanned by computer. Rules of analysis or algorithms are used by the computer to analyze the alphanumeric codes, rather than job data, to select training system features, sequence training requirements, group content, prepare behavioral statements or to meet many other requirements.

The goal of the NTSC training features selection project is to specify training device features based on job/task behaviors and cognitive content. The hypothesis was that too many things are happening concurrently in an aircraft cockpit to make rational decisions based on analysis of individual linear text-based tasks. What we expect to find is a heavy concurrency of activity, both psychomotor and cognitive, and when this concurrency is considered in the analysis process, these results vary greatly from the traditional approach. For example, a night attack pilot, in addition to operation of the aircraft in low level navigation, must contend with weather conditions, other external environmental factors, night vision goggles, FLIR, RADAR, target acquisition, target identification, weapon selection, arming and deployment, hostile threats, and an occasional emergency procedure. To develop an accurate portrait of the behaviors, environment, and conditions, the analyst must perceive all of the elements in

their concurrent relationships and translate them to some intelligible description of the required training device features. Figure 15 illustrates the training system features analysis process. Note that the video/audio codes are analyzed directly by the process and are converted into training device features. Iteration is provided for by the retrieval and review key feature built into the coding process.

The video/audio data base process has implications for the future of courseware development. (See Figure 16) DRC has already developed for NTSC a computer aided training analysis tool called Learning Objectives Classification Tool (LOC Tool) which could use selected behavior codes to create learning objective hierarchies. NTSC has another DRC developed tool for Media selection, that could use selected elements of the video/audio data base. DRC is currently developing a Course Outline Analysis Tool which could use selected elements to help select all the precursor, supporting, and development behaviors used for structuring courseware. Using these or similar tools (see Figure 17), the process could isolate instructional segments from the video/audio data base. These segments would be assigned to a given audiovisual media, such as CBT, and then organized into an instructional sequence. Video/audio data base segments and a requirements list would be delivered for computer based storyboarding by development personnel, and prototype courseware design would be underway while analysis continues for the remaining instructional requirements.

Summary

Until recently, traditional linear text-based procedures have served the training community well. The push and pull of interactivity, as well as cost, have driven us to look for more efficient and effective processes. (See Figure 18) Application of interactive technology to the data collection and analysis, and to the development of training products will provide the efficiency required. Time for development will be reduced, man hours per hour of instruction will be reduced, analysis results will be more consistent and traceable to the training requirements, and most importantly, interactive technology permits comprehensive analysis of the complex operational environment along with the more accurate representation of that environment in the instructional setting.

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A FRAMEWORK FOR ISD: THE TRAINING ENTERPRISE MODEL

Robert F. Bachert, Tenny A. Lindholm, Ken Evers

Agencies within the Department of Defense, Industry, and academia, presently use variations of Systems Approaches to Training (SAT) to develop original training systems. A myriad of task analysis methods are used in the necessary requirements analysis. After initial development, it appears that components or subsystems of training systems are developed in isolation, with little or no consideration as to interfaces or interactions with other components. Technology is continually presenting the challenges of systems upgrades and, hence, modifications to training. Technology may change the approaches to training. That is, all aspects of training tend to be evolutionary or changing. The Air Force is developing methodology for the definition and design of "total" training systems/enterprises. The methodology is based on the concepts of the systems approach and adaptive evolutionary systems. This paper discusses these concepts, the methodology, and their applications to the life cycle phases of training systems. In particular, the training enterprise model which serves as a framework for the ISD process is discussed, with emphasis on the management, planning, Total Quality Management (TQM), and system evolution aspects in relationships to ISD. The approaches being developed are generic and applicable to the development of any training system.

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A FRAMEWORK FOR ISD: THE TRAINING ENTERPRISE MODEL

Robert F. Bachert, Tenny A. Lindholm, Ken Evers

Introduction The Air Force is developing methodology, techniques, and tools for the definition and design of "total" training systems/enterprises. The methodology is based on the concepts of the systems approach and adaptive evolutionary systems. These concepts are discussed elsewhere [1,6,13,15,16,17] as to the application for systems analysis, research, design, and evaluation. For purposes here, a system is defined as:

> One or more humans, possibly aided by tools and/or machines, working to solve a problem or achieve a goal.

The systems approach is to combine selection and training with human engineering and machine capabilities to achieve cost effective, efficient systems with optimal performance. This approach considers the total system as well as all its components in a top-down, hierarchic manner. Suggestions have previously been made [17] "that training equipment can be significantly improved in both design and employment through adapting a systems approach which will integrate engineering and behavioral science data." Advantages of this approach for training systems development include:

1. component impact on total system performance can be evaluated
2. one disciplinary aspect is not overemphasized at the expense of others
3. decisions can be based on knowledge of effects on system performance rather than a single activity
4. retrofits and retraining can be minimized
5. better rapport among all life cycle team members
6. activity/function interrelations can be considered at each stage of the development/life cycle.

When discussing the concept and definition of systems, it is particularly important to observe that "There is no such thing as an independent objective perception of a system" [13]. Lendaris discusses in detail the definition of systems, the systems approach, perception of systems, and systems hierarchy. Systems hierarchy embodies the concept of suprasystems and subsystems, i.e., every system is contained within a larger system, and every system contains a subsystem (with obvious limits in each direction). Understanding these concepts is vital to the application of the systems approach to training systems design [10]. It can be postulated that the lack of understanding has led to the quagmire of task analysis methods. Methodology and techniques discussed in this paper have been developed to accommodate the above concepts and their applications to the planning and design of training systems. That is, training systems development must begin at a high-enough level within the enterprise to encompass all relevant training requirements. Deciding exactly how high remains the biggest challenge;

however, this decision must be made prior to systems design.

Just as the definition of system can vary, so also the definition of training system. Hays [10] says "A training system is the planned interaction of people, materials, and techniques, which has the goal of improved performance as measured by established criteria on the job." This definition is general enough to include training systems of all sizes and is certainly compatible with the systems definition previously given. It is not quite clear whether improved performance means added capability for students who will be new to a job or increased systems efficiency and effectiveness. Variables impacting human performance are discussed below.

For purposes here an enterprise is defined as: a system that produces products to achieve goals and *objectives, is influenced* by customers, and controlled by its suprasystem. Thus, an enterprise may be a system, or training system, consisting of only humans, or it may be a human/machine system. Size and complexity may vary from a single human (e.g., one person company) to a multinational organization (e.g., a Fortune 500 corporation). Humans build enterprises to solve problems related to larger (supra) enterprises for use as tools in these larger enterprises. The attempt has been to make that definition consistent with:

1. the concepts of Total Quality Management (TQM), which will be discussed in more detail below
2. the systems approach
3. the definition of training systems/enterprises.

An objective is to use the enterprise concept to orient the systems concept practitioners towards humans centered, adaptive, self-learning, and evolutionary type systems, in particular, for this paper, training systems.

From the above definitions, a training enterprise would be one or more humans, using tools and/or machines (media), to produce humans (or animals, etc.) trained for specific objectives internal to or external to the enterprise as determined by the user or customer. As will be discussed below, the Instructional System Development (ISD) process is a model (or set of guidelines) to be used by the enterprise to structure its activities for accomplishing the training.

Background Systems approach to training (SAT) and its successor ISD have been, and are being, used to develop training systems for a large variety of systems. Hays and Singer [10] provide a good history and evaluation of both approaches. The application of these procedures have been difficult for some practitioners and the reasons for this probably depend on a number of variables. Following are extracts from references [10,12] that provide a flavor of their viewpoint/perception for suggested problems and proposed solutions.

> "A third area of concern is improving the comprehensiveness, accuracy, and resolution of system function models for both normal and abnormal modes of operation." [12]

"Task analysis and instructional systems development methods are useful to determine what is to be trained but not explicitly to determine what is required to conduct training." [12]

"Improvements are needed in task analysis techniques and associated inferential methodologies." [12]

"A long-term research program should be initiated to provide tools for task analysis encompassing the description of operational tasks, the decomposition of task description into parameters and attributes relevant to the design objectives, and synthesis of the analytical data into requirements or specifications for system design." [12]

"Recent research supporting SAT and its offspring, ISD, reflects a return to the 1950's belief that the development of training is a complex dynamic problem requiring the techniques of systems analysis." [10]

"A true systems approach is necessary to design effective training programs, but rigid proceduralized methods should not be applied in every case." [10]

"What is necessary to make systems approaches to training work is guidance that helps training developers conduct the procedures recommended by ISD. Such guidance must be based on a valid model of training systems." [10]

This paper discusses a top-down systems approach and its application to the planning, design, and systems engineering of evolutionary training enterprises. In particular, a generic training enterprise model containing the ISD process and its utilization as a framework for training system program development will be considered.

The Training Enterprise There are two types of training enterprises. Each has as its purpose the goal of training humans as given by the above definition. However, one can be independent of the enterprise using its services and one may be contained within the customer's organization. For example, a university is independent of organizations that hires its graduates, while General Motors has traditionally trained its own employees through the GM Institute. There are both kinds of training enterprises within the government. Of course, an enterprise can be both independent of its customer yet contained within a customer parent organization. For example, the Air Training Command within the United States Air Force. Hence, when defining an enterprise it becomes important as to the scope of interest and perception.

Training systems developed for the Department of Defense can vary in size from maintenance training systems to large, complex, pilot training systems.

The Air Force, under its Specialized Undergraduate Pilot Training System program has been developing a Management, Planning, Analysis, and Definition System (MPADS) to be used for the development of adaptive, evolutionary training enterprises of all sizes and complexities. Portions of this program include the development of:

1. a framework for enterprise system analysis (3)
2. an enterprise model for training systems (7)
3. a model of the ISD process (9).

Figure 1 represents a top-level definition and bounding of a training enterprise. Figure 2 represent the next level decomposition of Figure 1. This model indicates the functions by which an adaptive, evolutionary training enterprise accomplishes its goal and produces its products. This model is described in more detail elsewhere (7).

<u>The IDEAL Methodology</u> IDEAL (Integrated Design, Engineer, and Analysis Languages) is a comprehensive methodology for describing, developing, and analyzing systems (7). Figure 3 shows the analytic framework presented by Bachert, et al, (3), and the application of IDEAL on the Depth dimension and MPADS on the Breadth dimension.

IDEAL has proven to be a unique, integrated approach that utilizes a top-down, structured technique to define and document the system of interest; a knowledge engineering technique to collect and organize system descriptive and task information; a rapid prototyping technique to perform preliminary systems performance analysis; and a sophisticated simulation technique to perform in-depth system performance analysis.

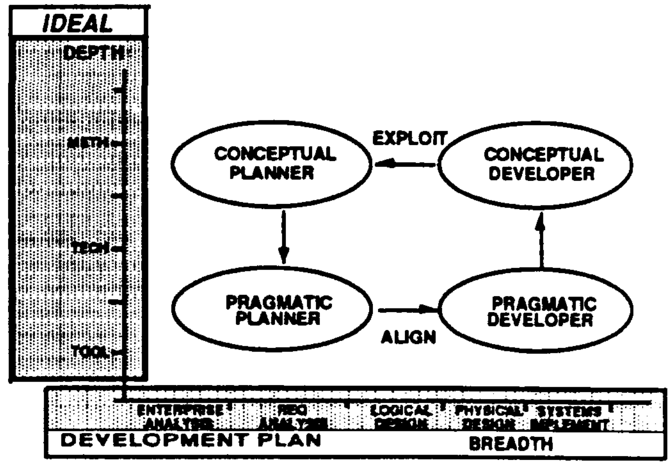

Figure 3. MPADS Analytical Framework: Planner, Developer Roles

IDEAL has proven to be an effective approach through the integration of proven techniques that have been developed and proven as stand alone methods. Among these are IDEF(0), *IDEF(1), SADT, and SAINT.* IDEF(0) and SADT are techniques for graphically describing a system from a functional and informational perspective. The SAINT simulation language provides a graphical representation of the dynamic performance of man-machine or generic systems. IDEAL integrates the static and dynamic representations through the use of a Performance Data Base.

IDEF(0) originated as a software requirements engineering technique. It has subsequently been extended to other applications where a top-down decomposition approach was needed to describe a system in order to examine how the system does or should function. The principal goal of IDEF(0) is to provide a structured

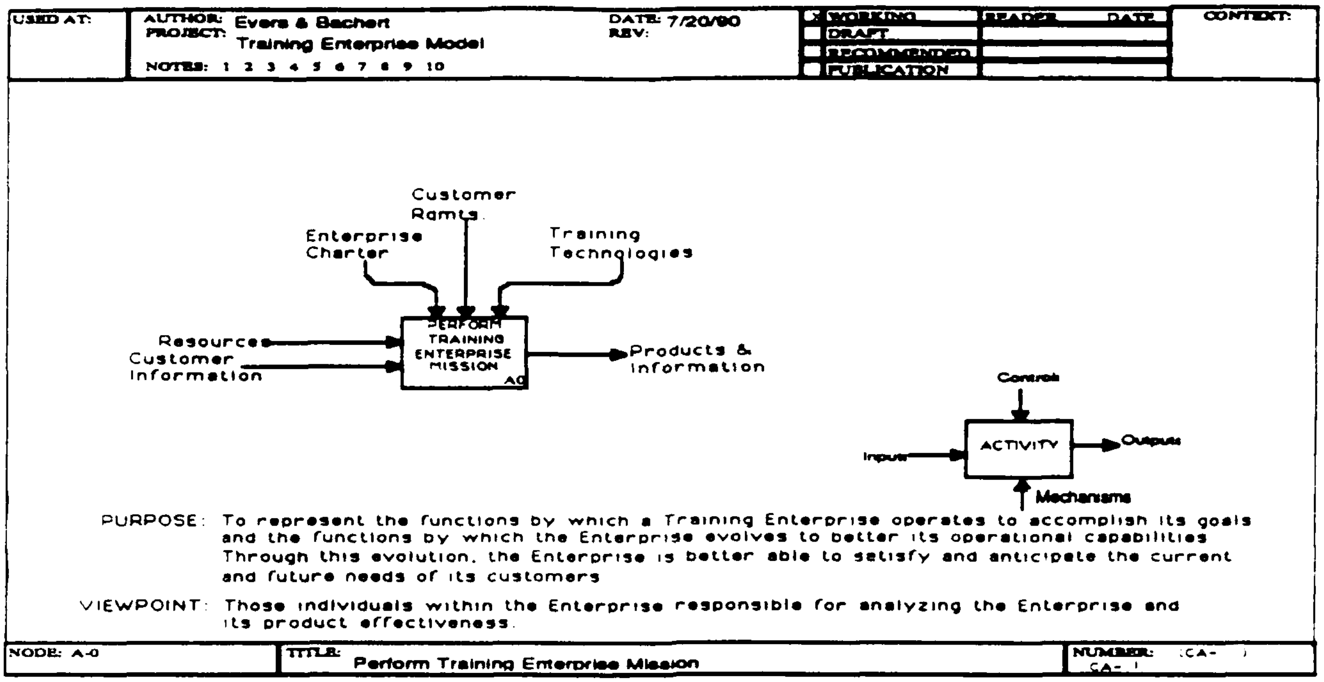

Figure 1. A-0 Diagram Model of Training Enterprise

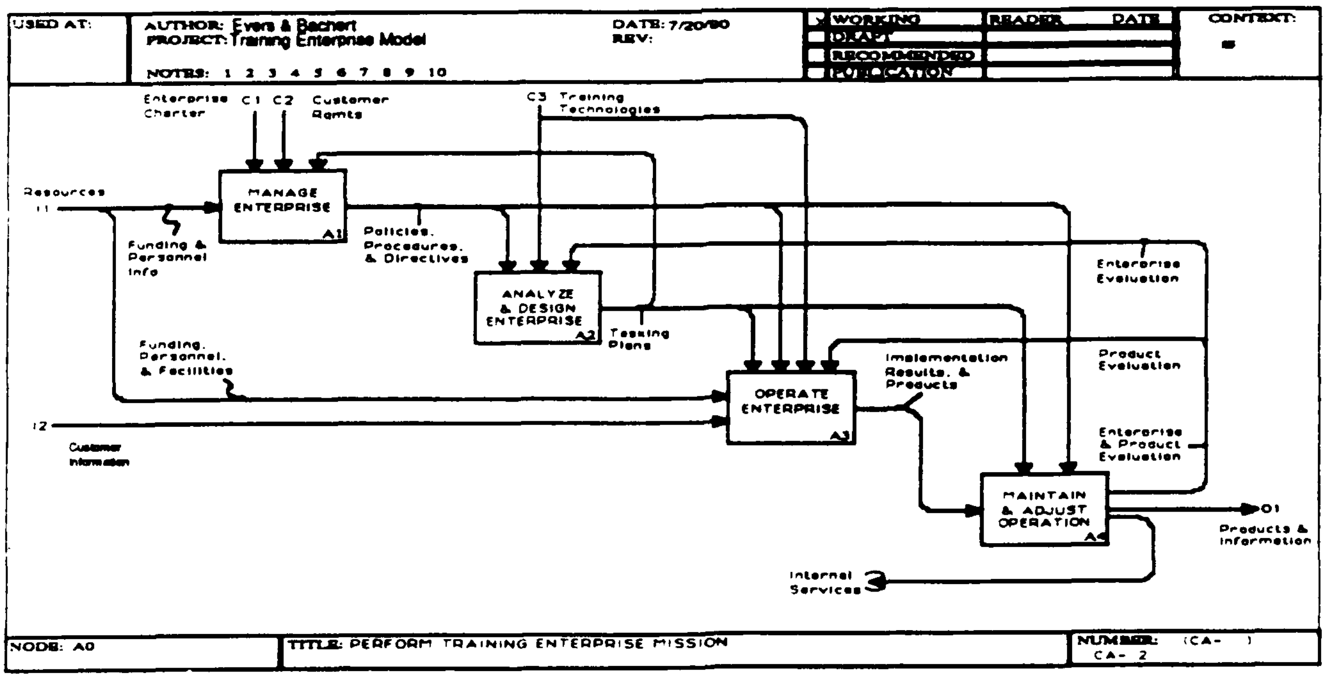

Figure 2. A0 Diagram of IDEF(0) Model of Training Enterprise

approach for breaking a complex system into more elemental components that are simpler to deal with. This is the basis for contemporary systems engineering practices where a multi-disciplinary team must be employed to design, develop, and produce a product.

An IDEF(0) model consists of an integrated set of diagrams that define the system boundaries and the system structure in a top-down manner. Diagrams consist of boxes (defining system function/activities/tasks) and of data arrows (defining relationships or information flow among the functions). The information associated with each activity is comprised of inputs to the activity, outputs produced by the activity, controls which represent the resources (people, equipment, software, hardware, etc.) which are responsible for the transformation. As illustrated in Figure 4, through the development of an IDEF(0) model, a system understanding is gained in a gradual, controlled manner through a graphic representation.

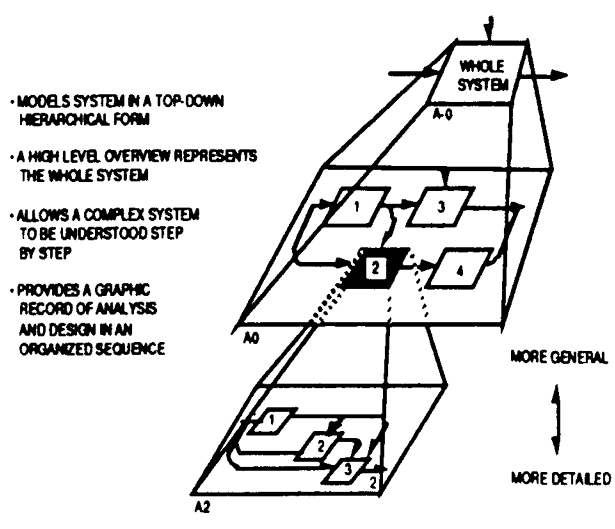

Figure 4. IDEF(0) Functional Model

The IDEF(0) and SAINT techniques are closely related in that the activities defined by IDEF(0) are the same as those represented in SAINT. Also, the data relationships among the activities in both techniques are the same. The primary difference between the two techniques is that IDEF(0) is a static representation of the system whereas SAINT provides a dynamic representation of the system. To form the link between the static and dynamic representations, the Performance Data Base (PDB) was formulated. The PDB is filled by specifying dynamic information for each sub-activity represented in the IDEF(0) model so as to define the performance characteristics of each activity along with the performance relationships among the activities. The dynamic representation of the system is then developed through the SAINT language by forming the basic network through the IDEF(0) model onto which the dynamic information from the PDB is integrated.

<u>Human Performance and Systems Design</u> If the purpose of training is to improve performance, then human performance variables must be considered when designing systems and their corresponding training systems. Holt and Stevenson (11) stated that:

> "Systems designers, when confronted with widespread human performance problems in their systems, search for a broader design approach. They sometimes believe that training equates to satisfactory human performance. There are at least two flaws in such an assumption. First, human

> performance in systems is the complex interactions of many variables, one of which is training... (The other variables are design, human machine interface, information transfer, environment, personal factors, supervision, and documentation.)"

These variable are not independent. Hence, when determining training needs the following issues must be considered:

1) Does the training system need to be evolutionary to accommodate an evolutionary system?

2) Where in the design process should training requirements be determined?

3) What trade-off analysis/questions for human performance variables should be done/answered?

4) What resources/systems analysis tools are available to answer issues 1 thru 3?

Requirements The training enterprise framework and analytic framework discussed above are used with appropriate requirements to design and develop an operational training system. Figure 1 and its textual explanation define what the training enterprise's mission is, i.e., what the enterprise is to accomplish, its purposes and objectives. DeGreene (5) gives the following definition of a requirement.

> "A statement of an obligation the system must fulfill to affect the mission. Requirements are expressed first in qualitative terms and progressively in quantitative performance terms relative to some criterion(ia). They further delineate the system mission."

Top level requirements for the training enterprise shown are:

1. Be an adaptive, evolutionary, self designing system.
2. Incorporate TQM.
3. Perform top-down long term and short term level planning for enterprise and product change and evaluation.
4. Perform requirements analysis for customer needs.
5. Incorporate ISD and simulation capabilities.
6. Be human performance and system effectiveness oriented.

DeGreen gives the following definition of function.

> "A general means or action by which the system fulfills its requirements. Functions are usually expressed in verb form. They are the expression of the *how* of the system. They are

conceived apart from implementation by men and/or by machines; in practice, they are usually expressed along with machine design implications."

The definitions given by DeGreene are basic terms in systems hierarchy and are equivalent to the IDEAL methodology and its application to systems requirements and design. As the enterprise is progressively decomposed into lower levels of detail, requirements can also be expressed progressively in quantitative performance terms. In the design phase the mechanisms of humans and/or machines are allocated; the requirements for these mechanisms have been predetermined. Requirements addressed by the MPADS framework models and IDEAL include:

Functions,
Data, Information, Knowledge,
Internal and External Interfaces,
Human/Machine Allocation,
Operations,
Performance.
Logistics,
Environment.

With the top-down, hierarchic decomposition, the various levels of requirements are well documented and mappable to the corresponding function, data, and management levels. Depending on the size and complexity of the function, different size teams may be needed to accomplish the activity or task. Thus, requirements for team design and training can be determined. Also it is possible to study and evaluate team, as well as individual, performance in relation to the eight variables previously discussed. This is a top-down task analysis.

Requirements for the training enterprise were that it perform requirements analysis for customer needs and incorporate the ISD and simulation capabilities. The methodology and techniques, discussed above to satisfy these requirements, are the same that should be used to perform customer requirements, task analysis for ISD, and dynamic analysis via simulation, i.e., system analysis. Figure 5 is an IDEF(0) node tree showing a further decomposition of the functions shown in Figures 1 and 2. It shows where, from a functional perspective, the various requirements are implemented. Note the ISD process indicated by the shaded areas. IDEF(0) diagrams (sub-models) exist for each branch of the node tree. The validation and further development of this generic model is in progress as part of the MPADS and SUPT programs.

Total Quality Management (TQM) The relationships between management, planning, problem solving, training systems development methodologies, systems analysis and modeling, and TQM must be well defined for TQM to be effective. This can be facilitated through the methodologies and tools described above to support the application of TQM to the training enterprise [1]. It is necessary to better understand an enterprise's structures, functions and performance in the context of a total/integrated operation that is continually changing. From this knowledgebase the training enterprise can set objectives, define strategies, and plan an effective application of a TQM process.

Using the framework components as a guide (the enterprise model is a reference model to be used with other

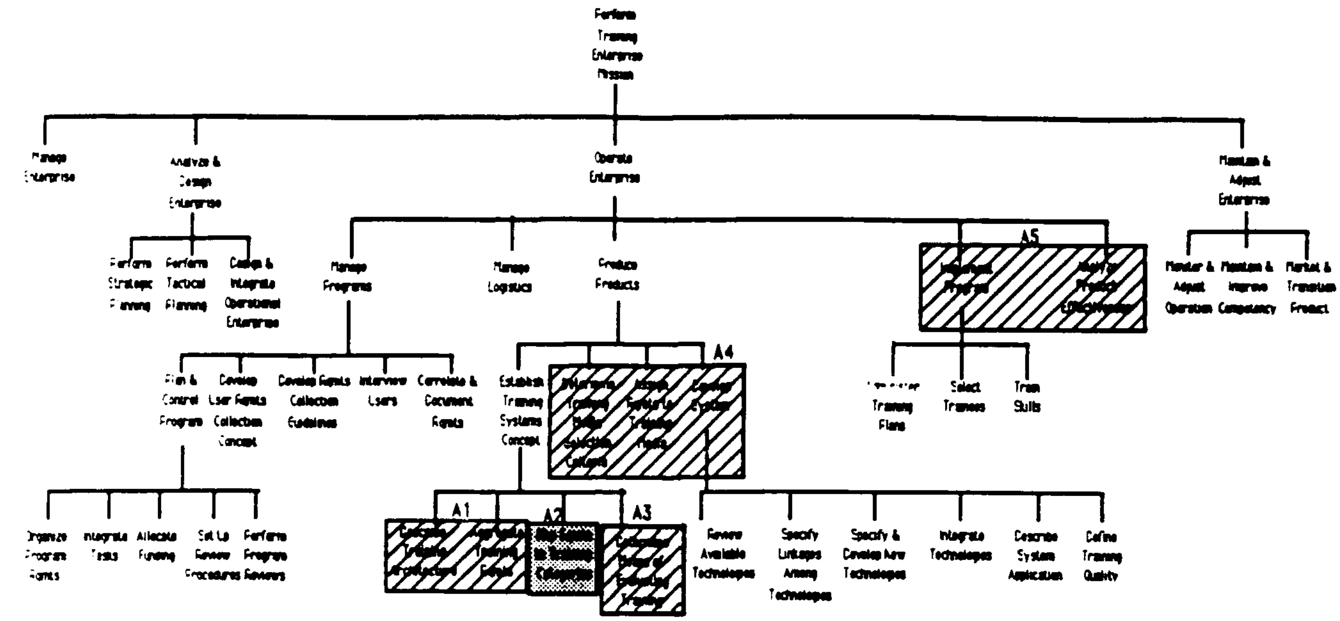

Figure 5. Training Enterprise Model Node Tree
Shaded function block correspond to ISD Process

framework models) the planning of TQM is accomplished as follows:

- All external and interna' inputs are identified and it is possible to trace what functions or components of the enterprise are impacted. For each function the quality and specifications of impacts can be evaluated.

- The capabilities, etc., of human and/or machine mechanisms necessary to accomplish the task can be planned.

- Controls are designed using the requirements of the process and mechanisms allocated.

- System or process related problems are addressed via modeling and simulation.

Since the framework models are top-down and each level of decomposition provides a greater level of detail, it is possible to plan for TQM considerations for various levels of organizational and functional structure. In training systems quality equates to human/system performance issues and the validity of simulations/simulators.

Summary This paper has discussed portions of the Air Force program to develop a planning system (MPADS) for the planning, analysis, design, development, test and evaluation, and the evolution of training enterprises. The concepts and methodology embodied in this system is the top-down systems approach. The basis of MPADS is a framework, or reference model, for describing, analyzing, evaluating, and designing large complex training enterprises. It is used as the "framework" for systems engineering, component development,

product development, enterprise design/operation, and enterprise management. Models derived via the framework (e.g., the training enterprise model) as part of MPADS will provide:

1. a clearer picture of what the training enterprise is doing and where it is going
2. scenario analysis that can be used to answer "what if" questions
3. reduced analysis time and elimination of the intuitive approach
4. an accurate picture of decision consequences
5. a "corporate memory" database
6. rapid answers to questions about the current status of organizations.

The planning system is being designed to consider the issues of defining problems/needs, planning for large complex training systems, and designing the appropriate organizational infrastructure necessary for an evolutionary adaptive system. The methodology, techniques, and tools discussed in this paper are applicable to all systems/enterprises.

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A TRAINING DEVELOPMENT ENVIRONMENT IN HYPERTEXT

C.G. Thronesbery, Ph.D.
Ron W. Rhoads

The development of training systems for the military requires the management of large amounts of information. The developer must ensure that the lesson being developed is consistent with the task being performed, the individual training plan, collective training plans, doctrinal sources, and other student reference sources. Often, the number of resource materials available to the developer is so large that it is nearly impossible for the developer to give due consideration to every source. The result is that the lesson is less complete and less powerful than if all sources had been considered. Furthermore, once a lesson has been developed, the developer needs to maintain records of the sources of his information in the event that a particular point is challenged. The information to be managed consists of text and graphics of varying size and complexity. Such information has not been addressed well by traditional computer software packages like word processors, data base management systems, and spreadsheets. Hypertext is designed to organize this type of information, but is often difficult to provide the reader with a clear enough structure so that he remains oriented and capable of performing a directed search.

A structure for a hypertext system is described which will serve as a training development environment. Specific screen designs and hypertext structures are presented which support training development. Assuming arrangements can be made for a large-display Macintosh system, a demonstration of a sample training development hypertext structure is anticipated.

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A TRAINING DEVELOPMENT ENVIRONMENT IN HYPERTEXT

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Hypertext is often useful for managing large amounts of heterogeneous information. One task which has extensive information requirements is training development. Consequently, a sample hypertext system is presented which supports training development.

When a large volume of heterogeneous data must be searched to find the information of interest, hypertext is often the information management technology of choice (Shneiderman, 1989). Unlike database management applications, which also allow large amounts of information to be searched, hypertext systems do not require a rigid record structure. In fact, the data can be so heterogeneous as to include computer graphics, video disk images, sound, etc. Hence the emerging term "hypermedia."

In their analysis of hypertext, Foskett (1990), McAleese (1989), Shneiderman (1989), and van Dam (1988) indicate that although the data may be heterogeneous, structure is required of hypertext data bases to promote readability. Thronesbery and Rhoads (1990a) indicate that hypertext development environments which expedite the construction of readable hypertext structures will probably be available at a future date. However, they indicate that before these environments can be constructed, a number of special-purpose hypertext structures must first be built. Consequently, the present paper describes how to construct a hypertext document system which will support training development. Hopefully, after a number of such systems have been described, generic properties of readable hypertext structures will become evident and can be incorporated into future hypertext construction environments.

In keeping with the theme of this year's conference, the current paper shows how to use the technology of hypertext for training development. Specific screen designs and hypertext structures for a sample hypertext document system are described which will support the specific needs of training development.

I. Training Development Requirements.

The developer of military training must manage a tremendous amount of information. He must consult sources of doctrine, task analyses, mission statements, training plans, and other training modules. The content of the lesson he develops must be consistent with doctrinal sources, which means that he must consult the appropriate Field Manuals (FMs) and Student Texts (STs). The selection of objectives for the lesson must be consistent with individual and collective training plans, e.g., Mission Training Plans (MTPs) and Army Training Evaluation Plans (ARTEPs). In the event that the training plan is not explicit enough to make a decision about selecting a particular objective, the training developer might need to consult a Mission Essential Task List (METL) and a Task Analysis Information Sheet (TAIS) in order to determine critical tasks for training. Finally, the developer must ensure that the current training module is consistent in format, content, and presentation sequence with the other lessons in the course. This latter problem is compounded if the developer is part of a team in which each member is developing a different portion of the

course. Because of this enormous requirement for information coordination, training developers often have several opened resource materials covering the tops of their desks, their chairs, their friends' desks, their friends' chairs, etc.

Moreover, the training developer is often expected to defend individual points covered in a lesson after a considerable amount of time has passed. He must identify the doctrinal source in which an exercise or objective is grounded. If he has not recorded this information rigorously, he will be required to repeat the entire process of researching the lesson module.

II. Difficulties in Meeting Information Requirements.

Because there are so many potential sources of information to coordinate, the training developer typically spends a lot of time consulting these sources and, despite his diligence, still overlooks some of them. For instance, because the developer has forgotten that a course he developed two years ago has a similar training module to the one he is currently developing, he might miss the opportunity to save himself a lot of work. Because he has doesn't have easy access to his co-worker's work-in-progress, he might miss an opportunity to coordinate an effective presentation style with the developer of a related training module. While he may work primarily with one or two doctrinal sources, he may overlook other manuals with small, yet valuable, sections related to the current lesson module. In other cases, the training developer might know of a source and intend to consult it, but be unable to locate it. Finally, because there are so many potential sources, it is often difficult to place the relevant portions of each source in proximity to one another so that they can be directly compared. To summarize, the training developer should consult a large number of references to develop a high quality lesson module, he spends a lot of time doing so, and he still misses a number of them. Thus, the efficiency and quality of lesson development suffer.

III. How Hypertext Can Help to Meet Requirements.

Hypertext is a technology which can enable its readers to locate specific information within a large body of widely varying types of information. Hypertext is a way of storing and presenting information, typically with the aid of a computer. In the typical hypertext system, a passage is presented which contains one or more highlighted terms. The reader may designate any highlighted term and subsequently see another passage which contains additional information concerning the designated term. Each new passage will, in turn, have highlighted words or phrases. For a more complete definition and an overview of a number of existing hypertext systems, Conklin (1987) has written a very useful review. Also, Thompson and Thompson (1987) have written a creative article to demonstrate the nature of hypertext to people who do not have hypertext systems.

By using a hypertext system containing the doctrinal sources, similar to that developed by Thronesbery and Rhoads (1990b), the training developer could locate information he might otherwise have overlooked, either because he was unaware of its existence or because he had simply forgotten about it. In addition, if he and his co-workers were using a shared hypertext data base, he could look at the portions of their work-in-progress which are related to his current lesson module. He would also be able to compare the modules in his course

to his training plan. Upon detecting ambiguities in the plan, he could consult sources like the METL and the task analysis to determine appropriate training objectives and lesson modules for the current course. Furthermore, if the hypertext system were implemented on a large-screen workstation with windowing capability, he could examine the information from a number of sources simultaneously. Finally, since hypertext can also function as an authoring environment, it can be used to develop the training module using hypertext links to identify the references upon which the objectives are based.

IV. Required Hypertext Properties.

While hypertext promises a tremendous increase in efficiency, it will deliver on that promise only if it is carefully structured to support the information requirements of the training developer. The following is a list of the most important properties the hypertext system must have to support a training developer:

- allow quick navigation to familiar locations within the hypertext document system
- provide cues where information can be found regarding a particular topic
- provide easy navigation among several sources related to a specific topic
- allow the simultaneous display of several windows of information so they can be compared to one another
- allow several training developers to view one another's work-in-progress
- allow work-in-progress to be accessed topically

V. Sample Hypertext Training Development Environment.

The proposed hypertext training development environment is a repository of doctrinal information, task information, training plans, and developed courses. The screen designs shown in the figures are from a demonstration system generated in Guide (a hypertext development environment by Owl International) on a large-screen Macintosh computer.

A. Document Structure.

The hypertext document structure is illustrated in Figure 1. The lessons being developed are represented on the left side of the figure while the reference sources are represented on the right side. Each major component of this hypertext system has an inherent structure which is emphasized and used for navigation within that component.

The Lesson Table of Contents (TOC) is a collection of previously developed courses and work-in-progress. When the reader designates (clicks on) a course name, a schematic of the lesson modules within that course will unfold below the course name. The schematic shows the logical sequences for the presentation of the lesson modules. Clicking any lesson module within the schematic will cause that module to be displayed in a separate window.

The lesson module is illustrated in Figure 2 in greater detail. There are three important divisions of the window displaying the lesson module: the title box, the lesson module itself, and the icon row.

First, the title box is included to ensure that the reader always has a clear identification of any lesson module he is viewing. The title box provides not only an identification of the contents of this window (the module name and lesson title), but it also shows the overall context within which it fits (the course title).

Second, the lesson module, the lower portion of the lesson module, is organized hierarchically to expedite the location of a specific objective of interest within the module. It can be displayed by designating the Show Text icon (from the icon row). This state of the lesson module is illustrated in Figure 2. The major divisions of the lesson are shown in boldface type. Clicking on a major heading causes the text and graphics associated with that heading to be displayed below the heading. In Figure 2, the reader has clicked on "Introduction," causing the introductory paragraph to be displayed below its boldfaced heading. Clicking on the paragraph will remove it from the display once again. This feature allows the reader to locate any specific portion of the lesson module quickly.

Finally, the icon row, just under the title box, provides the reader with the capability of navigating to other portions of the hypertext document system with relative ease. The row of icons provides easy navigation to other portions of the hypertext document system. By clicking on the PREV or NEXT arrows, the developer can look at the previous or next lessons in the course. By clicking on the Lesson TOC icon, he can view the Lesson Table Of Contents and course schematics illustrated in Figure 1. By clicking on the Index icon, the reader can view the topical Index, which is described below.

The compass rose icon (in the icon row) provides quick access to specific Index topics. Figure 3 illustrates the appearance of the lesson module when the compass rose has been designated. If the reader clicks on one of the topic names shown in Figure 3, the designated topic of the Index will then be displayed in a separate window. Notice that the compass rose is darkened in Figure 3, showing that it is the currently activated icon.

The Developmental References icon has been included to assist the developer in identifying the authoritative sources upon which he based the materials in the lesson module. Figure 4 illustrates the appearance of the lesson module when the Developmental References icon has been designated. If someone should challenge the information presented in the lesson module at a later date, the developer can click on the appropriate entry under "Developmental References," causing the original authoritative source to be opened at the appropriate passage. Thus, the developer can quickly show the source of the information he has presented in the training module. Notice in Figure 4 that the Developmental References icon has been darkened to indicate that it is the active icon.

The <u>Index</u> is included to provide the capability to search the entire hypertext document system topically. The Index is accessible from any window in the hypertext document system by clicking on the Index icon. When the Index is first displayed, the reader sees all the letters of the alphabet. By designating a given letter, he will see all the topics in the Index which begin with that letter. He can then click on the name of a topic of interest, displaying the names of all the locations in the hypertext system which are related to that topic. This includes work-in-progress, developed courses, doctrinal sources, task analyses, METL, and training plans. Clicking on the name of a reference source under an Index topic will cause the display of the designated reference in a new window.

With a large-screen display, the reader can place the Index window in the corner of the screen, showing the topic of interest. He can then use the Index as a

reading guide, clicking on each reference successively. If there is a need to compare and contrast sources, their respective windows can be placed side by side on the screen. This allows the training developer to perform a high level of analysis which is often difficult under normal circumstances. It is especially impractical when trying to compare passages which occur within the same paper-based book. Thus, creative use of a large screen can improve the analytical quality of the training developer's work.

Other sources within the sample hypertext document base include task analysis information (TAIS), training plan information (MTPs and ARTEPs), and doctrinal sources (FMs and STs). Each of the major sources shown in the right-hand portion of Figure 1 would have its own hierarchical table of contents, allowing the reader to navigate quickly to any particular passage. The appearance of a passage from these sources would resemble the lesson module shown in Figure 2. A passage would have a title box, an icon row, and paragraph headings. The title box would identify the passage. The icon row would allow rapid navigation to other parts of the hypertext system, and the paragraph headings, when designated by a mouse click, will allow the display of their associated paragraphs.

B. Computer Supported Cooperative Work Environment.

Because it can be a shared hypertext document system for a group of training developers, the demonstration system can be an instance of a computer-supported cooperative work (CSCW) environment. Essentially, this means that it assists a group of people in the sharing of information and the development of a large group project. In this instance, the large group project is a collection of courses. The work-in-progress training modules are stored in the hypertext document base, along with the completed courses.

Some discipline must be exercised to allow several people to use the same files. The first general rule to observe is that while a file can have multiple readers, it cannot easily have multiple authors. For that reason, it probably makes sense for the author to build his document in a private work area and then place a copy of that work in a public area as major portions are finished. For instance, assuming that a group of training developers was working on nodes of a local area network (LAN), the file would be edited in a private file storage area until a major portion is finished. At this time, the file would be copied into a common file storage area of the LAN. No one would be allowed to edit files directly on the common file storage area of the LAN. Thus, every file on the LAN could be accessed in a read-only fashion, allowing several people to access them.

The other general rule to observe is that configuration management should be exercised to ensure that entries into the common reading area are ready for viewing by the group and that updates are posted in an orderly fashion. A lesson module would not need to be completed before adding it to the common file storage area, but it should have most of the links required to perform topical searches. It should also have the icons in the icon row linked to the Index and Lesson TOC. This minimal linking prevents a reader of the file from becoming marooned from the remainder of the hypertext document base. For purposes of quality control, it might be desirable to have a single person designated to save a work-in-progress file into the common storage area.

While there are some CSCW projects which do not strictly adhere to these rules, they are used by computer experts in an experimental environment. Instances of large, experimental CSCW projects appear in Akscyn, McCracken, and Yoder (1988), who report on the KMS system, and Halasz (1988) and Trigg and Suchman (1989), who report on the NoteCards system. The people using these systems are highly experienced, knowledgeable computer professionals. Training developers, on the other hand, should not be expected to be as facile with a computer as the people using these systems. Also, because these systems are experimental, they have a higher tolerance for occasional difficulties. These rules simplify the exchange of work-in-progress, so that difficulties are kept to a minimum and fewer computer skills are required. For other management considerations concerning the construction of hypertext systems, see Rhoads and Thronesbery (1990).

C. Use as a Training Presentation Medium.

Depending on the way in which the lesson module has been constructed and the circumstances surrounding the presentation of training, the sample system could be used as a medium for presenting the training. The student can use the Lesson TOC to guide his navigation from one lesson module to the next. He can use the hypertext structures within a lesson module to view the materials prepared by the training developer. He can even take self-tests, the answers to which can be revealed by unfolding hypertext structures within the lesson module. Finally, if he is having difficulty with a particular point, he can follow the relevant reference links to read the doctrinal sources in more detail. The paper by Rhoads and Thronesbery in this volume describes a wide variety of options for using hypertext in computer assisted instruction.

VI. Conclusions

Training developers must manage a large amount of diverse information, and they often must cooperate with a number of others in their development efforts. When properly organized, hypertext is especially well suited to support the management of large amounts of diverse information. Furthermore, with the proper safeguards, hypertext can form the basis of a computer-supported cooperative work environment. Consequently, hypertext can assist training developers in managing training information and in cooperating with one another to develop training modules.

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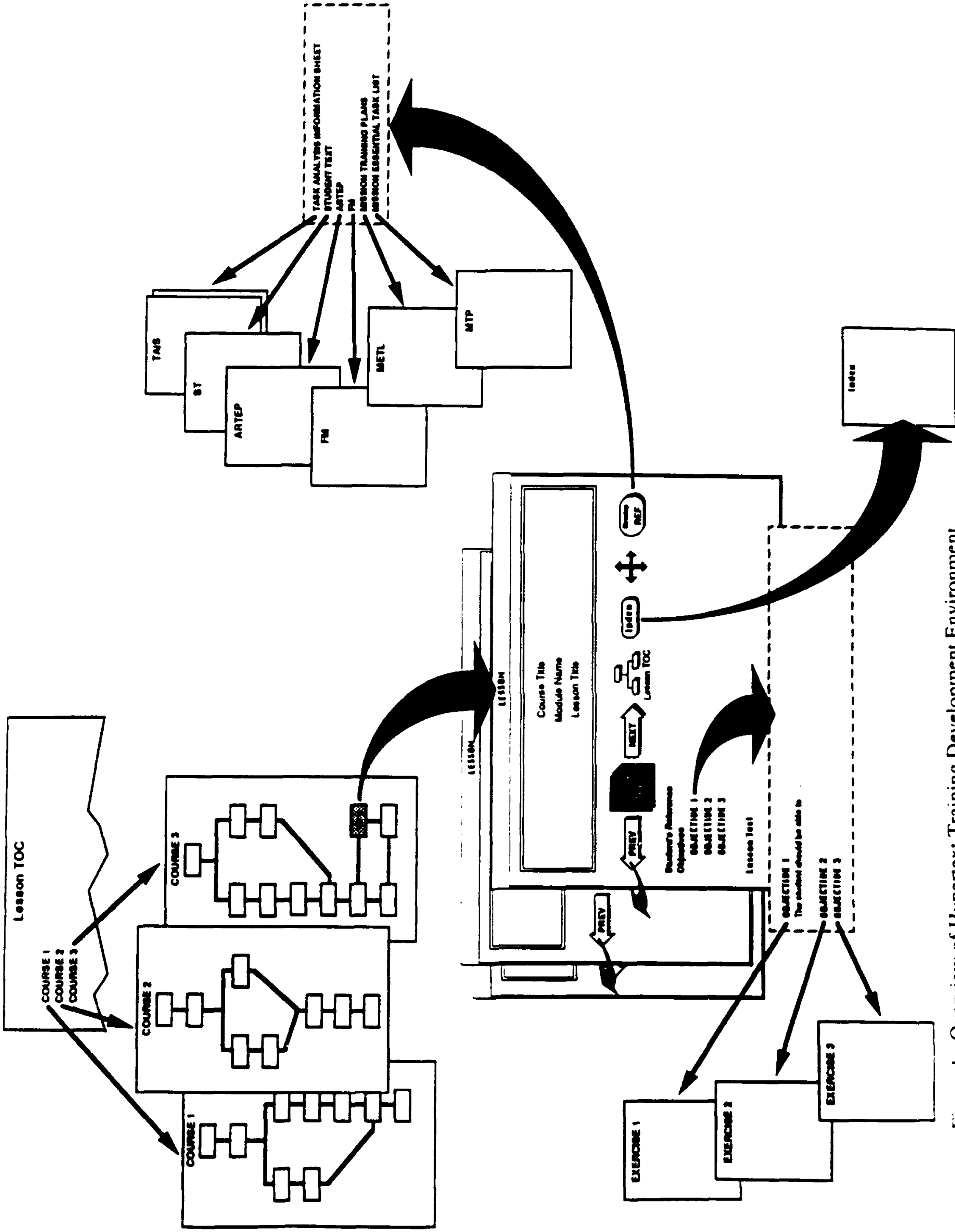

Figure 1. Overview of Hypertext Training Development Environment.

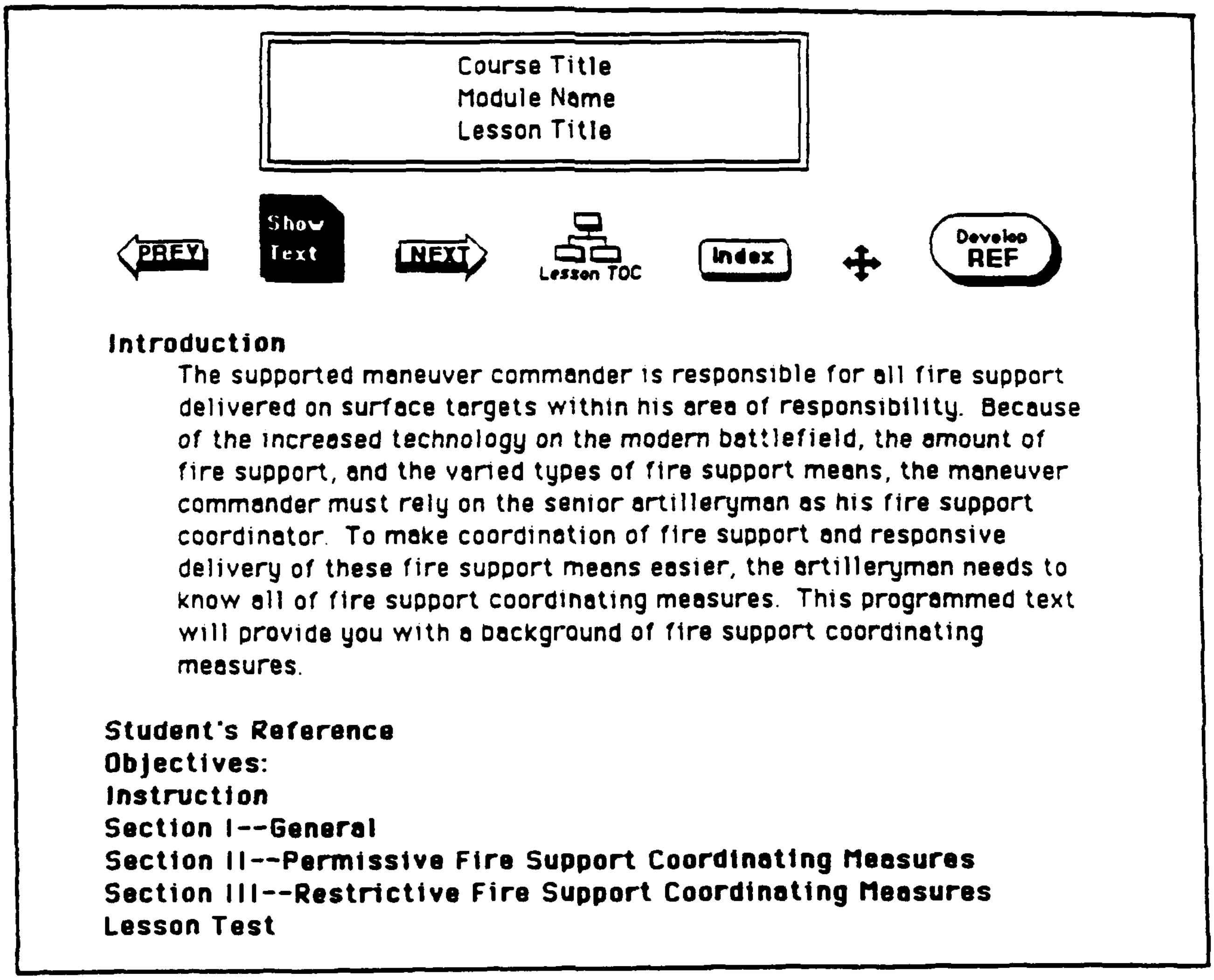

Figure 2. The Lesson Module with the Show Text icon activated.

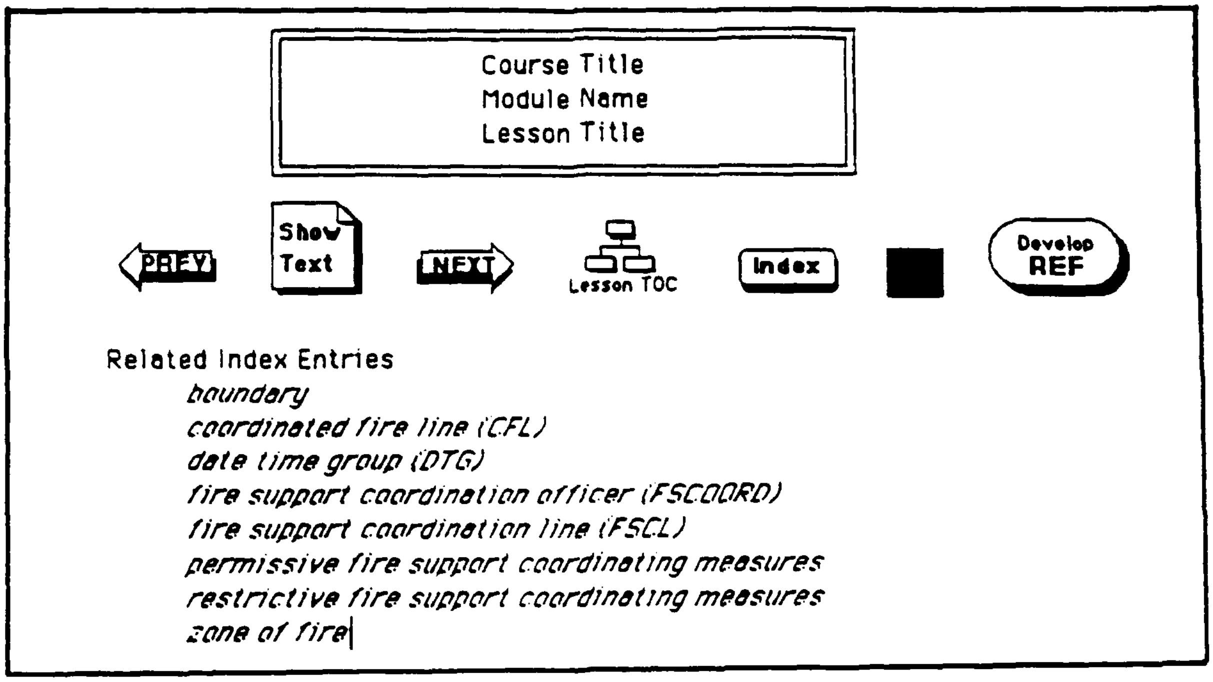

Figure 3. The Lesson Module with the Related Entries icon activated.

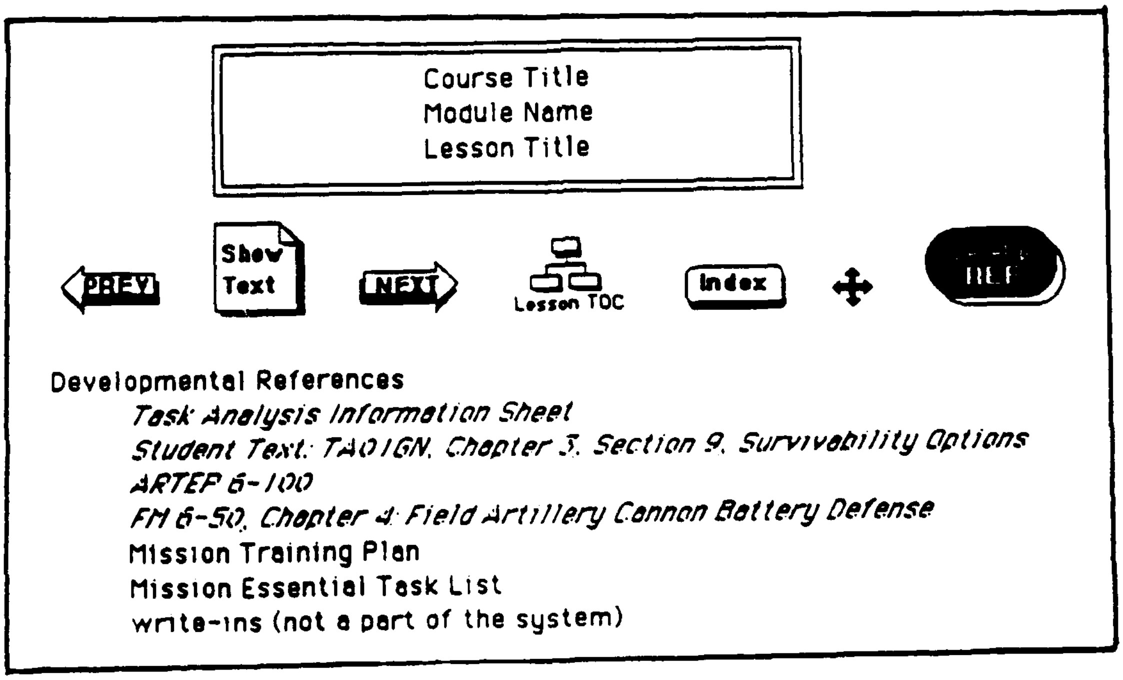

Figure 4. The Lesson Module with the Developmental References icon activated.

IDENTIFYING THE NEXT GENERATION AUTHORING SYSTEM: EVOLUTION OF AN AUTHORING ENVIRONMENT

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ABSTRACT

The Naval Sea Systems Logistics Center Detachment (NAVSEALOGCENDET) tasked the Naval Underwater Systems Center (NUSC) to form an authoring system evaluation team. The evaluation was intended to identify current industry capabilities relative to future NAVSEA/NUSC interactive courseware (ICW) authoring requirements, establish realistic criteria for an authoring system specification, and evolve a comprehensive authoring system specification for a competitive procurement. Due to the increasing scope of future ICW development requirements, it was determined that an authoring system would be needed that could accommodate the instructional characteristics of the Navy ICW, support the hardware requirements of the delivery system, and still allow an efficient authoring process that would reduce ICW production costs and shorten time lines for a large volume of courseware. The authoring system evaluation team was composed of both government and contractor representatives. The ultimate objective of the evaluators was to develop a comprehensive yet realistic functional specification for an authoring system procurement, rather than a comparative evaluation of specific authoring systems. Baseline criteria for an authoring system were formulated from current, conventional authoring system capabilities and requirements derived specifically from the unique development and hardware requirements of the Navy ICW. Functional categories included: interface features, display features, graphics features, audio/video features, input features, processing features, and testing features. Evaluation participants were to produce the sample lesson using their authoring systems. Each evaluation was conducted at the vender site over a period of two days. After the evaluation team completed its assessments, an authoring environment specification was finalized, an RFP drafted, and a competitive procurement initiated. The evolution from the initial baseline criteria to the final specification reflected some basic changes in philosophy regarding the authoring process. As a result, an authoring environment consisting of flexible productivity tools and functions in addition to the traditional authoring system was conceived. This "authoring environment" represents the next step in interactive training production.

ABOUT THE AUTHOR

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INTRODUCTION

The Naval Sea Systems Logistics Center Detachment (NAVSEALOGCENDET) tasked the Naval Underwater Systems Center (NUSC) to form an authoring system evaluation team. The evaluation was intended to identify current industry capabilities relative to future NAVSEA/NUSC interactive courseware (ICW) authoring requirements, establish realistic criteria for an authoring system specification, and evolve a comprehensive authoring system specification for a competitive procurement.

Current ICW production requirements necessitate custom development of course-specific authoring tools, such as display-capture routines, database structures, and courseware executables in the "C" programming language. This represents a time consuming and expensive slice of the ICW development cycle. Due to the increasing scope of future ICW development requirements, it was determined that an authoring system would be needed that could accommodate the instructional characteristics of the Navy ICW, support the hardware requirements of the delivery system, and still allow an efficient authoring process that would reduce ICW production costs and shorten time lines for a large volume of courseware.

Instructional features of the Navy courseware are characterized by the tutorial, demonstrate-practice, feature learning, hypothesis testing, and structured simulation instructional strategies. Delivery system hardware consists of custom procured, commercially available interactive videodisc systems. The delivery systems are composed of a 486 based processor; dual high resolution, 1280x1024 touch screen monitors; audio and video digitizing boards; and numerous peripheral input devices arranged in a cabinet intended to simulate the visual, spatial, and tactile characteristics of an AN/SQQ-89 sonar console (see figure 1).

The authoring system evaluation team was composed of both government and contractor representatives. The ultimate objective of the evaluators was to develop a comprehensive yet realistic functional specification for an authoring system procurement, rather than a comparative evaluation of specific authoring systems. The team sought to determine the extent to which current authoring systems could meet the baseline criteria and shape the authoring system requirements to reflect viable expectations.

EVALUATION METHOD

Baseline criteria for an authoring system were formulated from current, conventional authoring system capabilities and requirements derived specifically from the unique development and hardware requirements of the Navy ICW. Functional categories included: interface features, display features, graphics features, audio/video features, input features, processing features, and testing features.

A sample ICW lesson was then designed that incorporated many of the critical features of the baseline criteria. A flowchart, storyboards, and design specifications were formulated for the lesson; and sample graphics (both bit mapped and vector), digital audio files, and a DOS executable were produced to provide a realistic, prototype ICW lesson. The flowchart, storyboards, and design specifications required that the sample files and an existing videodisc (provided by the evaluation team) be utilized as part of the sample lesson. Evaluation participants were to produce the sample lesson using their authoring systems.

Upon completion of the sample lesson, a Commerce Business Daily (CBD) notice was drafted inviting all interested vendors of authoring systems to participate in the evaluation. As a result, five authoring systems were subsequently evaluated.

EVALUATION PROCESS

Each evaluation was conduced at the vender site over a period of two days. The evaluation team provided the flowchart, storyboards, design specifications, floppy disks with necessary files, and a videodisc to a vendor-appointed developer for implementation. The developer then authored the sample lesson while the evaluation team observed, asked questions, and participated peripherally. Each company produced different portions of the lesson in different ways, according to the characteristics of their system. The interaction between the developer and the evaluation team during lesson production was frequently more informative than anticipated. The evaluation team often offered possible solutions to authoring problems not previously considered by the developer. In addition, the process of working through these problems with different authoring systems also helped to clarify many of the Navy development requirements.

A key element of the evaluation was the evaluation sheet used by each team member. Each evaluation sheet contained a list of production features called for by the sample lesson. Each feature was referenced to the criterion within the baseline criteria on which the feature was based. As an evaluation progressed, evaluators made notes for each feature regarding the performance of the system on that feature and the potential impact on the corresponding criterion.

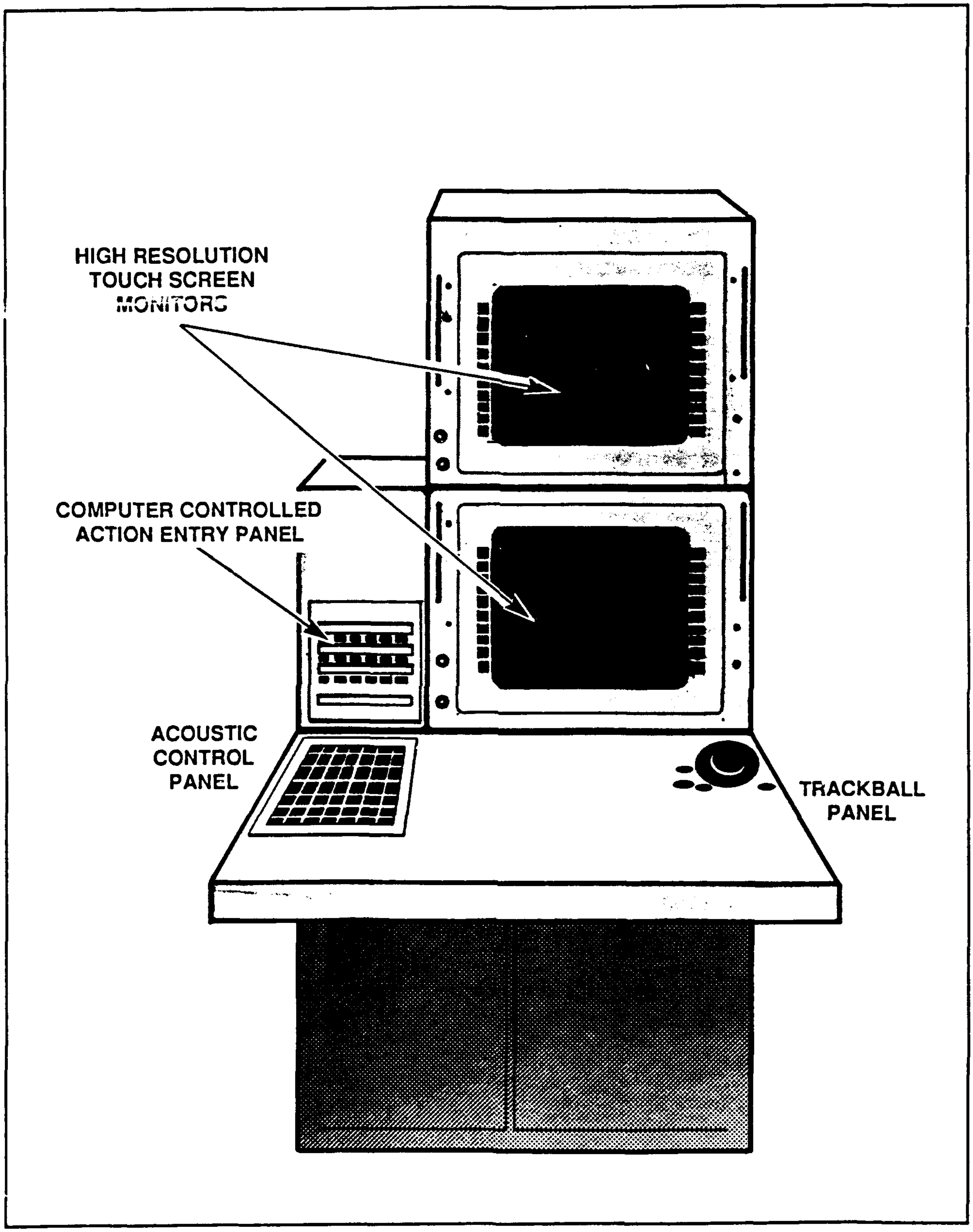

Figure 1. Interactive Video Delivery System

Upon completion of an evaluation, the evaluation forms were submitted to the team leader. The team leader consolidated the comments into an evaluation report and, in consultation with other team members, revised the criteria accordingly. Each evaluation report described the capabilities of the system, the extent to which it was able to accommodate the sample lesson, and the resulting modifications to the criteria.

After the evaluation team completed its assessments, an authoring environment specification was finalized, an RFP drafted, and a competitive procurement initiated.

SPECIFICATION DEVELOPMENT

The starting baseline criteria and the expectations of the evaluation team initially reflected an authoring system characterized by a single program from which an author would create courseware functionality. Over the course of the evaluation, however, it became apparent that this concept was inadequate. As the evaluations progressed and development requirements came into sharper focus, the scope of the authoring system (as previously envisioned) broadened to accommodate the emerging development requirements. The original concept of the authoring system was replaced by a conception of a more dynamic environment with a flexible range of authoring tools. The new concept included the original "authoring system" in addition to other development functions considered necessary for highly efficient courseware production. These functional elements include use of Microsoft Windows, productivity tools, extendibility, functional graphics, and rapid prototyping.

Windows. From a productivity standpoint, the evaluation team decided that the intercompatibility of windows applications would be valuable. The very nature of the authoring environment concept is dependent upon the intercompatibility of various development elements, such as graphics files, database structures, and courseware executables. This is the same principle on which the Windows environment is based. Thus, the requirement for the authoring environment to be within the windows framework is the first step toward the realization of the authoring environment concept. In addition, from a project administration standpoint, having the report generation and spreadsheet capability resident within the authoring environment has the potential of increased productivity.

Productivity Tools. The ability to create databases or groups of instructional templates would be necessary to significantly enhance productivity. Since a substantial portion of the intended ICW is based on previously defined instructional strategies, these strategies can be represented as templates or structures within the authoring environment, thus eliminating the need to recreate the structure for a strategy every time the strategy is employed in the courseware. While the concept of an instructional template is not new, the system's added ability to employ an instructional template and actually construct the course specific flow without the benefit of graphic files, audio files, video segments, and text files represents a unique and highly productive function. This virtual separation of content from flow enables the author to construct an assessable course executable prior to the completion of other production activities. This would allow lesson flow and branching to be tested prior to the insertion of content. The ability to create other types of course-specific templates is included in this requirement. The evaluation team appreciated the developer's need for productivity tools specific to the production process and, as a result, incorporated the requirement for a built-in template capability.

Extendibility. The evaluation team determined that developers would require the ability to create custom developed courseware elements and integrate these elements with the authoring system executables. For example, simulation elements frequently require development in a programming language such as "C" or assembler. The authoring system should be able to load and execute those elements in a manner simple for the author and transparent to the trainee. Therefore, the ability to utilize such elements was established as a requirement. The extendibility requirement also encompasses custom-developed, course-specific utilities. As an example, some of the Navy ICW will require the display and manipulation of LOFAR grams in addition to stand-alone LOFAR grams. Thus, a LOFAR gram generator utility is needed as a separate entity from the authoring system. Since the LOFAR grams are to be an integral part of the courseware, the LOFAR gram utility must be fully compatible with the authoring system from both a software and authoring standpoint. It is this relationship, separate yet fully compatible, that defines the utility as a part of the authoring environment and makes the extendibility feature the cornerstone of the environment concept.

Functional Graphics. Development requirements clearly indicated that courseware would have to simulate graphically the look and function of control panels. This involves dials, switches, meters, scopes, and other types of controls. Evaluators determined that these images, along with their corresponding functionalities, should be reusable. This meant that in addition to storing the image of a particular type of dial, its corresponding movements should be stored along with it. This would enable authors to construct functional control panels by linking previously created "functional" graphics using the authoring system.

Rapid Prototyping. It is often the case that developers learn development lessons too late in the production cycle. The ability to rapid prototype, or quickly produce portions of lessons, can provide valuable information regarding the feasibility of certain instructional or developmental approaches. This information can be used to avoid costly and time consuming re-development. The evaluators therefore decided to require a rapid prototype capability that would employ the previously described productivity tools.

In addition to these functional elements that help to define the concept of an authoring environment, there are several other features of the actual authoring process that the evaluators determined merited special attention in the functional specification. Testing and data collection features are described in detail because of numerous weaknesses discovered in this area during the evaluations. The ability to synchronize digital audio, video, and graphics became another requirement, as a result of problems encountered during the evaluations. The evaluators also identified symbolic representation of course structure as a requirement. It was determined that the ability to depict courseware flow and structure, as in a block flow diagram, was an essential development aid. Table 1 illustrates all of the categories and subcategories in the final functional specification formulated by the evaluation team.

CONCLUSION

The evolution from the initial baseline criteria to the final specification reflected some basic changes in philosophy regarding the authoring process. Traditional authoring systems of the last decade were stand-alone tools allowing designers and authors to create simple, tutorial type presentations. The design of the courseware was inhibited by the limitations of the authoring system. With the requirements of large scale, high level instruction delivered on an interactive system simulating a complex device, the authoring component of production has been redefined. As a result, an authoring environment consisting of flexible productivity tools and functions in addition to the traditional authoring system was conceived. This "authoring environment" represents the next step in interactive training production.

REFERENCES

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2. Authoring Environment Specification, N6604-91-R-2266, Naval Underwater Systems Center, NL, 12 April 1991.

Table 1. Authoring Environment Specifications

FEATURES						
DISPLAY	**GRAPHICS**	**AUDIO/ VIDEO**	**INPUT**	**PROCESSING**	**TESTING**	**INTERFACE**
Dual Monitors Video Playback Text Importing	Internal Graphics - Graphic Functions - Functional Graphics External Graphics - Graphic Overlays	Video Editor - Video Stills - Audio Channels Graphic Overlay Digital Audio Synchronization	Peripheral Input Serial I/O Touch Areas Questions - Response Submission - Answer Judging Multiple Inputs	Variables Branching External Executables Memory Resident Utilities Data Collection - Data Files Objective Tracking Computer Generated Sounds Error Checking	Tests - Test Data - Test Banks - Test Integrity Procedural Testing - Response Latency Questions Input Devices	User Interface - Editor Productivity Tools - Rapid Prototyping - Extendiblity Pilot Testing Help

AN ASSESSMENT OF TRAINING & EDUCATION MEDIA SELECTION MODELS

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ABSTRACT

A comparative analysis of current media selection models was conducted as part of an overall effort to improve key Instructional Systems Development (ISD) steps that would significantly benefit from automation and decision support features. The media selection step within the ISD process was chosen for in-depth evaluation of its automation requirements. The objectives of this study were threefold: (a) to compare and contrast the media selection models in general use by military, contractor, and civilian instructional designers; (b) to identify key features that impact media selection model automation; and (c) to develop a preliminary design of an automated media selection model that incorporates the requirements of as many of the reviewed media selection models as possible.

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AN ASSESSMENT OF TRAINING & EDUCATION MEDIA SELECTION MODELS

INTRODUCTION

The media selection analysis step of the Instructional Systems Development (ISD) process has been the focus of continual research by instructional designers and training developers. This research has led to countless attempts to develop workable models to manage the ISD process (Anderson, 83; Braby, 73; Kemp & Dayton, 85; Merideth, 65; Reiser & Gagne, 82). The ISD literature is profuse with media selection models and each new model developer approaches the subject with the belief that this attempt will be better than all previous models. Prior to developing a media model, the literature is reviewed, the shortcomings are pointed out, and a new model is created. Determining which model is the bestbecomes the subject of much debate within the ISD community.

The purpose of this effort was not to create another media selection model. The intent was to identify and evaluate the current models and to develop a flexible, automated environment in which the leading media selection models could be hosted. Much of the justification for this approach relies from past media selection research.

Several excellent reviews of the media selection research include Lumsdaine (1963), Lumsdaine and May (1965), Campeau (1967) in Briggs, Campeau, Gagne, and May (1967), Allen (1971), Saettler (1968), Meredeth (1965), and Tosti and Ball (1969). All of these reviews referred to the hundreds of studies that generally concluded with a finding of "no significant difference." These results were obtained because of a failure to control the complex interplay of instructional variables such as media, learner, subject matter, and course. These variables continually have been confounded in most of the media studies (Sorensen, Park, & Awtry, 1990). Nearly all educational and training media researchers concluded that basic well-designed media research has yet to be performed that would prove the efficacy of any medium of instruction over another. Of more fundamental concern was the general lack of agreed-upon media taxonomies and instructional design parameters in which to conduct that research. Accordingly, most media selection models were generally based upon limited research findings and substantial conjecture.

Until this fundamental research is performed, the best media selection environment that can be devised is one that is highly flexible in the manner that: (1) the media attributes (e.g., display characteristics, stimulus medium, level of behavior) and media (e.g., videotape, still/visual, part-task trainer) are defined and ssociated to each other; (2) the model's design is presented and executed by the user; and (3) the results are aggregated and presented for evaluation. If changes dictated by new research findings and new technological changes in media are to be incorporated into a model's logic, user-control of the media selection model is of prime importance.

Media Selection Models Analysis

The analysis described here identified and evaluated over 50 media selection models. Initially, as many different models as possible were identified and obtained for review. Candidate models represented a broad cross section of military, contractor, and civilian users, different levels of detail and comlexity, different end uses (e.g., front-end analysis versus curricula development, and different decision-making approaches e.g., matrix, flowchart, etc). Of special interest were models that had been automated. The models that are known to have been automated include 3306th Training Development and Evaluation Squadron (TDES), Automated Instructional Media (AIMS) Selection, Computer-Aided System for Developing Aircrew Training (CASDET), Melton, Man Integrated Systems Technology (MIST), Training Analysis Support System (TASCS), Technique for Choosing Cost Effective Instructional Procedures (TECEP), Training Efficiency Estimation Model (TEEM), and Training Technology Application-Decision Support System

(TTA-DSS).

Many of the models had been identified in previous reviews of media selection models. Most developers of new models included a review of previous models, using identified shortcomings as the basis for formulating new models. Notable reviews included those by Braby (1973), Briggs (1967), Main and Paulson (1988), Melton (1988), Reiser and Gagne 983), Romiszowski (1988), and Spangenberg, Riback and Moon (1973).

After initial evaluation and assessment, the list of 50 media models was reduced to 32. These 32 models selected for inclusion in this report are summarized in Table 1. Many of the 50 models initially identified were deleted because of inadequate or difficult-to-obtain documentation. Most of the deleted models are obscure and the difficulty in obtaining their documentation may be an indication that they are no longer available or used. Some of the deleted models had very poor documentation or just did not meet minimal criteria to be called a media selection model. Unfortunately, a few of the more desirable models were developed by contractors and were unattainable because of their proprietary nature. Altogether, the 32 surviving models represent a comparable cross section of the models in use today. The names associated with the models in Table 1 are those that are generally used to refer to them by instructional designers.

The second column in Table 1 indicates whether the model was intended to be applied within the context of training front-end analysis (FEA) or as part of traditional instructional systems development (ISD). Within the military, FEA requirements are typically met through contractors applying Military Standards and their related Data Item Descriptions (DIDs). ISD requirements are often achieved by government personnel using one of the many ISD manuals and pamphlets (Sorensen, 1990). As shown in Table 1, only 8 of the models are intended for FEA use as a large number of civilian school models on the list are not intended for this purpose. Also, the unavailable contractor models account for some of these low numbers.

The third column of Table 1 indicates the type of behavioral statement that the model is intended to analyze. The term behavioral statement is used throughout this report to refer to tasks, task elements, skills and knowledge, and learning objectives. Nearly all of the models required learning objectives as their input. Only 5 of the models were designed for use with tasks. Not surprisingly, all but one of these was intended to be used as part of FEA. Only the 3306th TDES and the TTA-DSS models performed the media selection process at the skills and knowledge level (Sorensen, 1987). The 3306th TDES model performed its analysis wholly at this level of detail. The TTA-DSS provided this capability as an option. Some of the models permitted analysis of both tasks and learning objectives.

All of the 32 models are designed for one of six basic forms in the decision-making process: (1) guideline, (2) worksheet, (3) table, (4) matrix, (5) matrix with weights, or (6) flowchart. These forms represent the interface that leads the analyst through the model's decision-making logic. The type of decision making form is indicated in column six of Table 1 and a detailed discussion of the forms follows. Almost all of the models incorporated a single version of the decision making form, e.g., the AIMS model used a single matrix with weights. However, a few of the models employed multiple versions of a decision making form. In these "multiple form" models, the behavioral statements were initially categorized and a different version of a decision making form was applied to the category. Two approaches to categorization were found in the models: one approach assigned the behavioral statements to a type of learning category (e.g., cognitive, affective, psychomotor) and the other approach made the assignment to a phase of learning category (e.g., actuate motivation, transfer of learning, provide feedback). The model requirements for these approaches are shown as columns four and five in Table 1. These approaches are discussed later followed by a review of the attributes and questions that were used in the media selection models. Similarly, an assessment of the media outcomes that were obtained

Table 1. Summary of Media Selection Models

MEDIA SELECTION MODEL	INTENDED USE	TYPE OF BEHAVIORAL STATEMENT	LEARNING CLASSIFICATION REQUIRED	PHASES OF LEARNING REQUIRED	TYPE OF DECISION MAKING FORM	REFERENCES
3306th TEDS (1987)	FEA/ISD	Skills & Knowledge	No	No	Flowchart	Procedures Manual: 3306th TES
AFM 50-2 (1979)	ISD	Learning Objectives	Yes	Yes	Multiple Form	Instructional System Development
AFP 50-58 (1978)	ISD	Learning Objectives	Yes	Yes	Worksheet and Table	Handbook for Designers of Instructional Systems
AIMS (1983)	FEA/ISD	Tasks or Learning Objectives	Yes	No	Matrix with Weights	Kribs, et al (1983)
Allen (1967)	ISD	Learning Objectives	Yes	No	Table	Same
Anderson (1983)	ISD	Learning Objectives	Yes	No	Flowchart	Same
AV-8B (1981)	FEA	Learning Objectives	No	No	Matrix	Hosteller, et al (1981)
Boucher, et al. (1973)	ISD	Learning Objectives	No	No	Table	Same
Bretz (1971a)	ISD	Learning Objectives	No	No	Flowchart	Same
Briggs & Wager (1981)	ISD	Learning Objectives	Yes	Yes	Worksheet	Same
CASDAT (1983)	FEA	Learning Objectives	Yes	No	Matrix	Ace (1983)
Cavert (1972)	ISD	Learning Objectives	No	No	Guideline	Same
Durham, et al. (1974)	ISD	Learning Objectives	Yes	No	Worksheet & Table	In Ely (1980)
F-16 (1981)	FEA	Learning Objectives	Yes	No	Multiple Form	Gibbons, et al (1981)
Gerlach & Ely (1971)	ISD	Learning Objectives	Yes	No	Worksheet	
Goodman (1971)	ISD	Learning Objectives	No	No	Guideline	

Table 1. Summary of Media Selection Models (Concluded)

MEDIA SELECTION MODEL	INTENDED USE	TYPE OF BEHAVIORAL STATEMENT	LEARNING CLASSIFICATION REQUIRED	PHASES OF LEARNING REQUIRED	TYPE OF DECISION MAKING FORM	REFERENCES
Heinich, et al. (1989)	ISD	Learning Objectives	No	No	Guideline	
Kemp & Dayton (1985)	ISD	Learning Objectives	No	No	Flowchart	
Levie (1975)	ISD	Learning Objectives	No	No	Guideline	
Lonigro & Eschenbrenner (1973)	ISD	Tasks	Yes	No	Table	
MCDECO P1553.1A	ISD	Learning Objectives	Yes	No	Table	
McConnell (1974)	ISD	Learning Objectives	No	No	Matrix	
Melton (1988)	FEA/ISD	Tasks or Learning Objectives	No	No	Matrix	
MIST (1985)	FEA	Tasks	Yes	No	Matrix	Herlihy, et al (1985)
Reiser & Gagne (1983)	ISD	Learning Objectives	Yes	Yes	Flowchart	Also in Gagne, et al (1988) and Interactive Courseware Management Plan
Romiszowski (1988)	ISD	Learning Objectives	Yes	No	Flowchart	
TASCS (1987)	ISD	Learning Objectives	No	No	Matrix with Weights	
TECEP (1978)	ISD	Learning Objectives	Yes	No	Multiple Form	Braby, et al (1978), Branson et al (1975)
TREM (1981)	FEA	Tasks	No	No	Matrix	Jorgensen (1981)
Tosti and Ball (1969)	ISD	Learning Objectives	No	No	Guideline	
TTA-DSS		Tasks, Learning Objectives, or Skills & Knowledge	Yes	Yes	Matrix	
Wilshusen & Stowe (1970)	ISD	Learning Objectives	No	Yes	Table	In Briggs and Wager (1981)

Table 2. Summary of Media Selection Models by Decision Making Form

GUIDELINE	WORKSHEET	TABLE	MATRIX	MATRIX WITH WEIGHTS	FLOWCHART	MULTIPLE FORM
Cavert (1972)	AFP 50-58 (1978)	Allen (1967)	AV-8B (1981)	AIMS (1983)	3306th TDES (1987)	AFM 50-2 (1979)
Goodman (1971)	Briggs & Wager (1981)	Boucher, et al (1973)	CASDAT (1983)	TASCS (1987)	Anderson (1983)	F-16 (1981)
Heinich, et al (1989)	Gerlach & Ely (1971)	Durham, et al (1974)	McConnell (1974)		Bretz (1971a)	TECEP (1978)
Lavie (1975)		Lonigro & Eschenbrenner (1973)	Melton (1988)		Kemp & Dayton (1985)	
Tosti & Ball (1969)		MCDECO P1553.1A	MIST (1985)		Reiser & Gagne (1983)	
					Romiszowski (1988)	
			TEEM (1981)			
		Wilshuser & Stone (1970)				

from the models will be discussed as well as the use of media selection models within the context of a course of instruction.

Decision-Making Process

Other media selection model reviews (Gagne, 1982 and 1983; Main and Paulson, 1988; Melton, 1988; and Romiszowski, 1988) have identified a number of different decision making forms or formats. This review differs from the others in terms of the number of models reviewed and the purposes for which the reviews were performed. In this review, format categories have been identified that best characterize model types from an automation standpoint.

Across all models, seven different types of decision making forms were identified: (1) guideline, (2) worksheet, (3) table, (4) matrix, (5) matrix with weights, (6) flowchart, and (7) multiple form. Table 2 summarizes the media selection models by decision making form. Detailed descriptions of each of these forms follow.

The guideline decision making form is the most unstructured and the most difficult to format for automation. Examples of these models include Cavert (1972), Goodman (1971), Heinich, Molenda, and Russell (1989), Levie (1975), an Tosti and Ball (1969). Primarily, these models, as well as a number of others that were rejected for inclusion in this study, were initial attempts at developing selection models. As Romiszowski (1988) has pointed out, the 1970s was the decade for media selection. Some models in this form (Tosti and Ball, 1969) are probably best classified as research products and not fully developed models intended for application. These models are mostly narrative in nature and provide little, if any, firm direction or aids to perform the selection process. This decision making form was rejected from consideration for automation. The worksheet decision making form is more structured; however, each worksheet is unique to the media selection model. Models that employed this approach include AFP 50-58 (1978), Briggs and Wager 1981), and Gerlach and Ely (1971).

The AFP 50-58 (1978) model is a complex worksheet. After classifying the learning objective into categories of concrete and abstract, the instructional analyst must then determine media for each of three stages of learning; early, middle, and late. Different presentation mode decisions are then made for each category. Presentation mode entries on the worksheet do not lead to a recommended set of media. Rather, the instructional analyst has to mentally, and with the aid of a media directory, combine the pattern of presentation mode choices into a best medium. If this pattern of selections were used by the model to match up to patterns in a pre-set media pool, then this model would represent a matrix decision making form. The Briggs and Wager (1981) model is a true worksheet. This format is unique to this model and is set up to record the analyst's decisions in a narrative manner. The worksheet decision making form is considered to be too variable and unique across models to be consistently automated. Moreover, this approach is generally too open-ended and subjective in its application.

A table decision making form is similar to the following matrix form. A table has media attributes and media arranged in the rows and columns of a matrix. However, the values obtained at the intersection are not clear and are typically qualified with notes and side comments about the goodness of fit. This form could be automated if more precise and consistent values were used.

Some of these table models can be easily converted to a matrix by assigning numeric values to the decision points. For example, models that use high, medium, and low at the decision points can be converted to values of 1, 2, and 3. In this manner, the model could be used as a matrix with weights form. Models that belong to this decision making form include Allen (1967), Boucher, Gottlieb, and Morganlander (1973) MCDECO P1553.1A, and Wilshusen and Stone (1970).

The matrix decision making form is the first form type that can be readily automated. The AV-8B Model is an example of a matrix form. Models in

this category have rows and columns that include media attributes or characteristics and media categories or media. At their intersection, an "X" or yes indicates a match between an attribute and a medium. A match can then be made between a behavioral statement's attribute set and the media pool's attribute assignments to find the best medium. The media can be rank-ordered by the number of attribute matches to identify alternative media. Models that use this form include AV-8B (1981), CASDAT (1983), McConnell (1974), Melton (1988), MIST (1985), and TEEM (1981).

The matrix with weights decision making form is similar to the previous form, except a numerical value is entered into the matrix. This form type can also be automated. The AIMS model uses this approach in that numerical values correspond to a predetermine Likert scale that ranges from 0 to 5. Zero indicates no match between the attribute and the medium. The values from 1 to 5 indicates some degree of match. A "1" indicates the lowest match and a "5" indicates the highest match. The scale points have different names to indicate different attribute metrics to be measured. Media choices are made by averaging the attribute values and rank-ordering the results. In addition to AIMS (1983), this form type includes TASCS (1987).

The flowchart or decision tree is another decision making form. Examples of this form include 3306th TDES (1987), Anderson (1983), Bretz (1971a), Kemp and Dayton (1985), Reiser and Gagne (1983), and Romiszowski (1988). In this form type, the user is led through the decision-making process via a series of questions. The questions can be either linear or branching. In all of the flowchart models found, the final decision at the end of the questions was a media class, not a single, best medium. Each media class or category included a number of media examples. From an automation standpoint, the flowchart can be converted to a matrix. One way to correct the flowchart method is to change yes/no questions to "1s" and "0s" in the matrix as was done by the Reiser and Gagne model. The 3306th TDES model consists of seven linear questions to make hardware decisions, followed by five branching questions to determine media, and is connected to a matrix format.

Three of the models evaluated (AFM 50-2, 1970; F-16, 1981; and TECEP, 1978) required more than one decision making form. All of the forms required by a model were of the same type. There are two "matrix with weights" forms required by the F-16 model. In this model, learning objectives are first classified into hands-on (training devices) and academic categories. A unique matrix with weights is then used for each category of learning objectives.

One of the matrices used in the TECEP (1978) classifies the learning objectives into 12 types of learning and a different matrix algorithm is applied to each type. Both of these models require an initial learning classification capability to categorize each learning objective. A description of a learning classification capability that will meet both model needs was developed. In addition to the learning classification capability, the AFM 50-2 (1979) model requires a capability to assign learning objectives to learning phases. This model requires learning objectives first be assigned to one of six types of learning. Learning objectives are then assigned to the learning phases of presentation, practice, and feedback. It must be noted in evaluating the AFM 50-2 model, that using the previous decision making form description, this model is really a table. It is assumed that the values (Yes, P, No, and N/A) can be converted to numerical values (3, 2, 1, and 0).

Learning Classification Schemes

Table 3 provides a summary of the learning classifications used by some of the media selection models. The type of learning classification is an important factor in many of the models as shown in that Table. Learning classification is used here to represent the type of learning outcome that the behavioral statement represents. The number of classifications vary from the three high-level categories of cognitive, psychomotor, and affective as used by AIMS (1983), Anderson (1983), and

Table 3. Summary of Selected Media Selection Models by Learning Classifications

AFM 50-2 (1979)	AFM 50-58 (1978)	AIMS (1983)	Anderson (1983)	CASDAT (1983)	Durham, et al (1974)	P-16 (1981)
Associations and Discriminations	CONCRETE Motor association and chains	Cognitive	Cognitive (Knowledge) Rules, Principles Concepts, Definitions, Discriminations, etc.	Familiarization	Cognitive (Factual Information)	Academic
Verbal Chains	Discriminations between actual people, events, or objects	Psychomotor		Fact	Affective (Values, Feelings, Emotions)	Training Device
Motor Chains	Classifications: classifying actual objects	Affective (attitudinal)	Psychomotor (Skills) Manipulation, Physical Coordination, etc.	Concept	Psychomotor (Body Movement)	
Classifying, Rule Using, and Problem Solving	Demonstrating a rule by non-verbal manipulation of objects		Affective (Motivation) (Attitude Change)	Rule/Procedure		
Perceptual Motor Skills	Solving problems by non-verbal manipulative acts			Principles		
Attitudes, Opinions, and Motivations	ABSTRACT Verbal chains and association					
	Verbal/symbolic discriminations					
	Classifications: classifying verbal/symbolic elements					
	Using rules involving language or symbols					
	Problem-solving involving language or symbols					

Gerlach and Ely (1971)	Lonigro and Eschenbrenner (1973)	MCDECO P1553.1A	Melton (1988)	Reiser and Gagne (1983)	TECEP (1978)
To Identify	Learning Factual Information	Identifying	MENTAL SKILLS: Knowledge	Teach a Skill (Mental or Motor)	Recalling Bodies of Knowledge
To Name	Learning Multiple Discriminations	Discriminating	Comprehension	Attitude	Using Verbal Information
To Describe	Learning Principles Concepts, and Rules	Defining, Explaining Attitude Demonstration	Application	Verbal Information	Rule Learning and Using
To Order	Learning Procedures	Sequencing	Analysis		Making Decisions
To Construct	Performing Skilled Perceptual Motor Acts	Making Decisions	Synthesis		Detecting
To Display Attitudes		Manipulating	Evaluation		Classifying
To Perform Motor Skills			Attitude Learning		Identifying Symbols
			PHYSICAL SKILLS: Hand/Eye Coordination		Voice Communication
			Gross Motor Skills		Recalling Procedures, Positioning Movement
			Verbal Communication		Steering and Guiding--Continuous Movement
					Performing Gross Motor Skills
					Attitude Learning

Table 4. Summary of Selected Media Selection Models by Learning Phases

AFM 50-2 (1979)	AFP 50-58 (1978)	Briggs and Wager (1981)	Romiszowski (1988)	TTA-DSS
		Instructional Events:	Instructional Events:	Instructional Events:
Presentation	Early Stage of Learning	Attention/Motivation	Presenting the Stimulus	Activating Motivation and Gaining Attention
Practice	Middle Stage of Learning	Present the Objective	Directing Attention and Other Activities	Informing Learner of the Objective
Feedback	Late Stage of Learning	Recall Prerequisites	Providing a Model of Expected Performance	Directing Attention, Enhancing Learner Modalities
		Provide Learning Guidance	Furnishing External Prompts	Stimulating Recall of Prior Knowledge
		Elicit Performance	Guiding Thinking	Providing Learning Guidance
		Provide Feedback	Inducing Transfer	Providing Meaningful Cues for Storage
		Assess Performance	Assessing Attainments	Providing Stimuli With Distinctive Features
		Enhance Retention and Transfer	Providing Feedback	Enhancing Retention
			Transfer of Learning	Providing Cues for Retrieval
				Transfer of Learning
				Shaping and Eliciting Performance
				Assessing Performance, Providing Feedback

Durham (1974) to the very detailed, 12-category TECEP model. Some of the learning classification schemes are well-known and established. The AFM 50-2 (1979) and AFP 50-58 (1978) models are based in part on the learning classification scheme of Gagne; the Melton (1988) model is based on Bloom (1956); and the TECEP (1978) model is based on Aagard (1976). Interestingly, the Reiser and Gagne (1983) model does not use the complete Gagne (1985) scheme of learning categories.

For most of the models, learning classification is used as a selection attribute or question in the model. However, for some models, the learning categories created by the classification scheme become the basis for employing a different media selection algorithm. These models are considered as "multiple form." As previously indicated, the TECEP (1978) model requires the classification of learning objectives into 12 types of learning. A different media selection matrix is then applied to each type of learning. A similar classification approach is used by the AFM 50-2 (1979) model. In this multiple form model, learning objectives are classified into 6 elements of learning strategies.

The F-16 (1981) model represents a special case of learning classification. This multiple form model, as well as the AV-8B (1981) model, was developed in response to a front-end analysis requirement to perform media selection in accordance with military specification MIL-T-29053B. The media selection data item descriptions (DI-H-25717 and DI-H-25720) require a model that separately evaluates hands-on and academic media requirements. The F-16 (1981) model requires the learning objectives to be separated into two categories: academic and training device. Two different matrices are then applied to the two learning objective sets. In the AV-8B (1981) model, the developer uses the same matrix to perform both analyses.

For these three multiple form media selection models, an automated learning classification capability similar to that used in the Learning Objectives Classification Tool (1989) would greatly assist the classification process. Keywords could be used in the same manner to assign the behavioral statements to the appropriate categories.

Learning Phases

Another critical design element of media selection models is the assignment of learning phases to learning objectives. Table 4 shows the five models that employ this approach. The phrase "phases of learning" is used broadly here to indicate the stages or events of instruction. As with learning classification schemes, phases of learning are used in some models as attributes and in at least one model as separate categories that require application of different media selection algorithms.

In addition to the learning classification requirement described previously, the AFM 50-2 (1979) model further classifies each learning objective by the learning strategy elements of presentation, practice, and feedback. For each learning classification and learning phase set a different media selection matrix is applied. The AFM 50-2 model is the only model found that results in a multiple form designation. No automated job aid to help perform this assignment seems possible.

Media Categories

Table 5 shows the media incorporated in a sampling of models. Some of the models cluster media by categories. The categories represent generic or psychological media capabilities (e.g., still visual, tutorial media, sound/moving visual, etc). Within these categories are found the actual media channel or hardware from which to choose (e.g., slides, CAI/CMI, television, etc). The MIST (1985) model is the only model that uses generic media throughout (e.g., audiovisual motion with feedback, etc).

Course Requirements and Media Selection

Few models uses course requirements as an analysis component of the media selection process. When mentioned as a criterion, this media selection dimension is typically addressed in

Table 5. Summary of Selected Media Selection Models by Media

3306th TDES (1987)	AFM 50-2 (1979)	AFP-50-58 (1978)	AIMS (1983)	ALLEN (1967)
Category: Hardware Cutaways Mock-ups Animated Panels Trainers Simulators Category: Print Manual/Job Aids Programmed Text Technical Orders Graphics Category: Still Visual Transparencies Slides Filmstrips Category: Exhibits Models 3-D Objects Category: CAI Terminals Touch Screen Interactive Video Category: Audio Tape Cassette Category: Sound/Still Visual Sound/Slide Filmstrips Category: Sound/Moving Visual Video Tape Sound Movie Television	Category: Classroom Instructor Lecturer Demonstrator Tutor/Coach Teaching Interview Category: Instructional Aids Overhead Projector 35mm Slides Chalkboard 8mm Movie (silent loop) Category: Multimodal Media Prenarrated Slides (with stop) Prenarrated Filmstrip Slide/Workbook/Audio Cassette Movies (sound) TV (cassette) Category: Print Books Computer (words & numbers only) Programmed Instruction Booklet Microfiche Category: Peer Role Playing Discussion Group Tutor/Coach Category: Simulation Actual Equipment Trainer Gaming Interactive Computer (plasma terminal) Case Study Category: Actual End Items	Category: Audio Radio Tape Recordings Records Listening Lab Variable Speech Tape Recordings Category: Visual Filmstrip (silent) Motion Picture as Repetitive Loop (silent) Category: Audiovisual Slides with Sound Filmstrip/Sound Television Motion Picture Motion Picture as Repetitive Loop (with sound) Category: Graphics Charts Diagrams Graphs Illustrations/Drawings Photographs Category: Exhibits Cutaways Mock-ups Models Projected Images Opaque Projections Overhead Transparencies Slides Category: Tutorial Media CAI/CMI Programmed Text Teaching Machines Learning Lab Paper Simulations Category: Environmental Media/Aids Simulator Part-Task Trainer Whole-Task Trainer Procedures Trainer Games Role Play Category: Print Media Textbooks Microform	Workbook Lecture Slides Slide/Tape Audio Tape Random Access Slides Motion Picture Video Tape Syncro-Pulse (Cue-See) Videodisc Teaching Machine 2-D Mock-up 3-D Mock-up Procedures Trainer Part Task Trainer Team Trainer Weapon Systems Trainer High Fidelity Trainer Realia (Actual Equipment) CAI: TICCIT CAI: PLATO CMI/Workbook	Still Pictures Motion Pictures Television 3-D Objects Audio Recordings Programmed Instruction Demonstration Printed Textbooks Oral Presentation

Table 5. Summary of Selected Media Selection Models by Media (Concluded)

AV-8B (1981)	BOUCHER, et al. (1973)	F-16 (1981)	MCDECO P1553.1A	MIST (1985)
Programmed Text	Overhead Transparencies	Academic Media	Blackboard	Instructor
Storyboard Text	Audio Tapes	CAI + Lesson Guide	Charts, Posters	Passive Audio
Sound Slide	2 x 2 Slides	CAI + Videotape + LG	Transparencies	Active Audio
Video Tape	Sound Slides	CAI + Videotape + Part Task Trainer + LG	Slides	Print Instructions w/o FDBK
Video Disc	Filmstrips	Interactive Part Task Trainer + LG	Filmstrips	Print Instructions/Oral FDBK
CAI/CMI	Sound Filmstrips	Random Access Slide + LG	Animated Transparencies	Print Instructions/Print FDBK
CAI/CMI with Peripheral Equipment	Motion Pictures	Motion Picture + LG	Animated Panels	Print Reference Material
PTT	Sound Motion Pictures	Videotape + LG	Mock-ups	Image Projection Still
Simulators	Microform	Videodisc + LG	Training Films	Audiovisual Still w/ FDBK
Aircraft	Teaching Machines	Tape Slide + LG	Instructional Television (ITV)	Audiovisual Still w/o FDBK
Instructor w/Low Category Visuals	Video Recording	Suitcase Projector + LG	Audio Recordings	Audiovisual Motion w/ FDBK
Instructor w/High Category Visuals	Live Television	Workbook + LG	Sand Tables	Audiovisual Motion w/o FDBK
	Slow Scan TV	Color Workbook + LG	Terrain Models	Visual Computer Still w/FDBK
	Printed Material	Workbook + Slides + LG	Simulators Procedures Trainer Mock-ups	Visual Computer Still w/o FDBK
	Programmed Text	Workbook + Audio + LG	Actual Equipment	Visual Computer Motion w/ FDBK
	Paper Simulations	Programmed Text + LG	Computer Supported Instruction	Visual Computer Motion w/o FDBK
	Charts	Training Manuals + LG		A/V Computer Still w/ FDBK
	Display Boards	Model/Actual Equipment + LG		A/V Computer Still w/o FDBK
	EC II	CFT + LG		A/V Computer Motion w/ FDBK
	Audi/Pointer	CFT + Tapeslide + LG		A/V Computer Motion w/o FDBK
	CPS 48	Lecture + LG		Static Display w/o FDBK
	Universal Process Trainer	Lecture + Audio + LG		Dynamic Display w/o FDBK
	Models Mock-ups	Lecture + Visual Motion + LG		Physiological Trainer Internal
	Back Lighted Panels	Lecture + Model/Actual Equipment + LG		Physiological Trainer Audio
	Animated Panels	Lecture + Student Response System + LG		Physiological Trainer Visual
	Simulators	Tutorial + LG		Symbolic Stimulation w/ FDBK
	Realia	Tutorial + Audio + LG		Trainer
	Computer Assisted Instruction	Tutorial + Visual Motion + LG		Simulator
		Tutorial + Model/Actual Equipment + LG		Operational Equipment
		Seminar + LG		Operational Equipment w/ FDBK
		Seminar + Audio + LG		
		Seminar + Visual Motion + LG		
		Seminar + Model/Actual Equipment + LG		
		Training Device Media		
		Panel Mock-up		
		Cockpit Mock-up		
		Stick & Throttle Trainer		
		SMS Trainer		
		Avionics Display		
		2-D Device		
		RWR Trainer		
		ICPT		
		CFT		
		EPT		
		DSS		
		ASPT		
		SAAC		
		OFT		
		OFT + NVS		
		OFT + DRLMS		
		OFT + EW		
		WST		
		F-16 A Aircraft		
		F-16 B Aircraft		
		3-D Model		

broad terms. Only TASCS (1987) and CASDAT (1983) evaluate the media choices within some context of course usage. The amount and ease of media use within the intended course can be an important selection criteria. This is an especially important step if a cost/benefit type of analysis is to be performed on competing or alternative media.

Media Selection Model Design

Figure 1 represents a preliminary design of the automated media selection model. As shown, there are four major functions that the design would support. The first function is a media selection model decision aid. A user of the proposed system may choose a media selection model already resident within the system or the model can be entered using the system's development function. If the user does not know which model to use, this decision aid can be used to assist in selecting the best model. The media selection model decision aid is a logic tree which leads the user through a series of questions. At the conclusion, the user will be presented with one or more models that fit the user's analysis parameters.

The second function provides for the development of a System Data Set. This development is a three-step process: (1) a new System Data Set is defined with a name and description; (2) a media model is selected for the System Data Set; and (3) the System Data Set is populated with Behavioral Statements, either by sorting from existing Behavioral Statements not already included in a System Data Set or by manually entering new Behavioral Statements.

The development of a media selection model is the third function and consists of the following steps: (1) defining a new model with a name and description; (2) identifying the structure (single-form or multi-form) and the types of decision making forms to be used; (3) selecting the actual forms to be used, either generic blank forms or currently existing forms in other models; (4) modifying the forms, if needed; blank forms must be populated with appropriate attributes, attribute categories, media, media categories, questions, question categories, weights, question-media weights, and flow rules; (5) selecting the type(s) of Behavioral Statements that the model will analyze; (6) determining what type of Learning Classification Scheme is appropriate, if any; and (7) building the Learning Classification Scheme, either from scratch or by copying and modifying ones from other models.

Media selection model application is the fourth function and has eight analysis steps which are described below:

(1) Select Media Selection Model. The instructional analyst selects (or creates) a media selection model for the System Data Set. The models that are available within the system are described in Table 6. The analyst may use any of these models or may enter another model using the previous model development function.

(2) Assign Behavioral Statements to Form Data Set. If the model assigned to the System Data Set is a multiple form structure, a Form Data Set is created for each decision making form. If the model is single-form, then there is only one Form Data Set created. Each Form Data Set is named and defined by the analyst. The Media Model's Learning Classification Scheme is applied to the System Data Set's Behavioral Statements to assign Types of Learning. At the same time, if Phases of Learning are required, they are manually assigned. If the model is multiple form, this serves to assign each Behavioral Statement to one of the Form Data Sets.

(3) Evaluate Behavioral Statements Using Model. For each Behavioral Statement, the appropriate decision making form is applied and attributes or questions are selected. In the matrix type of forms, the analyst manually compares each attribute to the Behavioral statement and marks it as yes or no. In the flowchart form, each question is answered yes/no in a branching manner that ultimately leads to completion.

(4) Determine Initial Media. The matrix type of decision making forms apply the attributes selected against the weights for each Behavioral Statement and calculate a value for the media. The media are given a rank

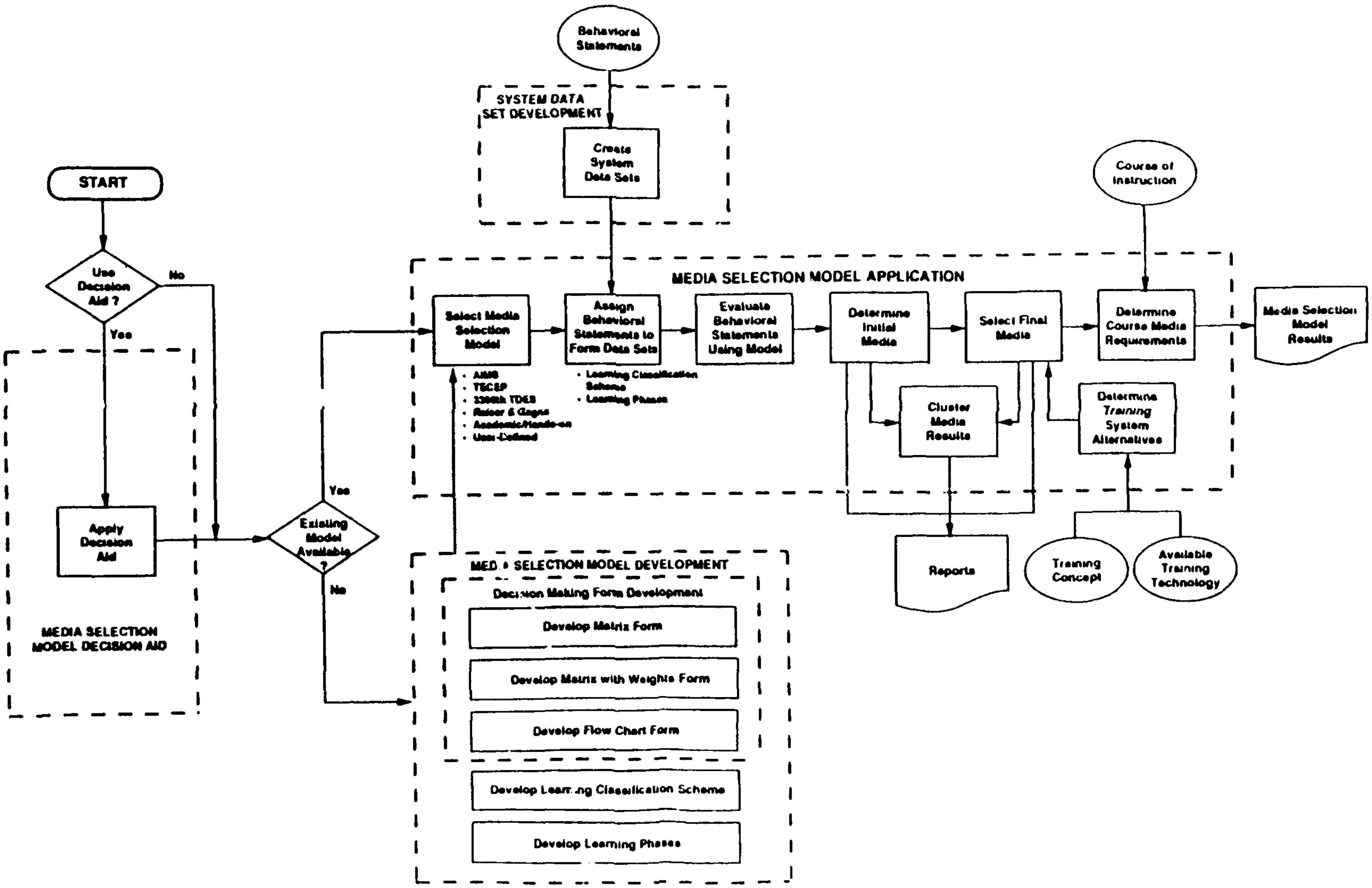

Figure 1. Preliminary Media Selection Model Design

Table 6. Summary of Selected Media Selection Models of Merit

MODEL CHARACTERISTICS	SELECTED MODELS AIMS	REISER & GAGNE	330 :h TDES	ACADEMIC/HANDS-ON	TECEP
Types of Behavioral Statement Evaluated	Tasks Task Elements Skills and Knowledge Learning Objectives	Learning Objectives	Skills and Knowledge	Tasks Learning Objectives	Learning Objectives
Learning Classification Scheme Usage	Classify Behavioral Statements into 3 Types of Learning Attributes	Classify Learning Objectives into Gagne's Categories of Learning	None	Classify Tasks or Learning Objectives into Academic and Hands-on Categories	Classify Learning Objectives into 12 Learning Algorithm Categories
Number and Type of Decision Making Forms	1 Matrix With Weights	1 Flowchart	1 Flowchart	2 Matrices	12 Matrices
Number of Attribute Categories and Attributes	Categories: 7 Attributes: 43	Categories: N/A Questions: 11	Categories: 2 Questions: 12	Analyst Selected From Attribute Taxonomy	Categories: 9 Attributes: 36
Number of Media Categories and Media	Categories: 0 Media: 22	Categories: 25 Media: 46	Categories: 8 Media: 24	Analyst Selected from Media Taxonomy	Categories: 2 Attributes: 77
Documentation	Kribs (1983)	Reiser & Gagne (1983) Reiser (1981) Reiser, et al (1981) Gagne, et al (1981) TRADOC Cir 351-86-1 Gagne, et al (1988)	3306th TES (1987) Hritz and Purifoy (1980) Hritz, et al (1980)	MIL-T-29053B Data Item Description: DI-H-25717B	Braby (1978) Aagard (1976) Branson (1975) TRADOC Pam 350-30 NAVEDTRA 106A

order, and the first 10 media became the initial media set. In the flowchart form, the pattern of yes/no answers to the questions points to a particular group of media, which becomes the initial media set.

(5) Determine Training System Alternatives. The analyst may choose to have several Training System Alternatives for the System Data Set. These can also be thought of as final media versions; for each Behavioral Statement, a final medium is selected for each version. Each version has a name and description and can be independently modified to optimize media utilization.

(6) Select Final Media. For each Behavioral Statement, the analyst manually selects a final medium to go with each Training System Alternative. These may be selected from the Behavioral Statement's initial media set or else from the general media database.

(7) Cluster Media Results. From time to time during the media selection process, either initial media or final media may be sorted in a wide variety of ways. The sort statements are called clusters and may be stored. The results are used in ad hoc reports to aid the analyst in making media assignment decisions.

(8) Determine Course Media Requirements. For each Training System Alternative, the course has a separate schedule and every lesson in it has a separate lesson media set. The analyst develops lesson media sets by examining the final media of all the Behavioral Statements in the lesson and manually selecting one or more for lesson media set. Clustering and ad hoc reports may play a role in the analyst's decision-making. A course schedule may also be modified to optimize media utilization.

CONCLUSIONS

In conducting this study, over 50 media selection models were identified and evaluated. Thirty-two of these models were further evaluated and documented. The models represent a cross-section of military, contractor, and civilian education approaches to media selection. Nearly all of the models are designed to evaluate tasks and learning objectives. Twenty-eight of the 32 models are intended to be used with learning objectives.

Seven different decision making forms were identified: (1) guideline, (2) worksheet, (3) table, (4) matrix, (5) matrix with weights, (6) flowchart, and (7) multiple form. The first three forms are too unique in application to be readily automated. Each of these forms is tailored to the model's requirements and utilizes formats that vary widely across different models. Moreover, models that use these forms tend to provide a loose analysis audit trail and lead ultimately to more subjective results. These approaches do not provide sufficient analysis justification of results required by most military training decision makers.

The table decision making form is similar to the matrix form. Converting the tables decision values to yes/no responses or to a numeric weight permits their inclusion in the proposed design.

The remaining four decision making forms can be hosted by the proposed design. These decision forms represent 17 of the 32 models evaluated. Most of the military models are represented in this group.

A single version of a decision making form is used in 29 of the 32 models. The remaining 3 models (AFM 50-2, 1979; F-16, 1981; and TECEP, 1978) use a multiple form. These models use more than one version of the same form. Assignment to the different forms is performed using one of two approaches.

The above three models use a learning classification scheme to create subsets of behavioral statements (i.e., tasks, learning objectives, etc.). This assignment of all behavioral statements into separate form-unique categories precedes application of each form's decision making logic. It is recommended that an automated learning classification capability be embedded in the proposed media selection program. This capability would be similar to that used in the Learning Objectives Classification (LOC) Tool. This job aid would: (1) standardize the assignment process using keywords, (2)

provide an audit trail of assignments, and (3) increase the accuracy and speed of assignment. Assignment to both categories and attributes would be provided by this capability.

The second assignment approach uses learning phases to create behaviorial statement categories. The AFM 50-2 (1979) model was the only multiple form model that uses this approach. No automated capability is deemed feasible to meet the requirements of this approach. Accordingly, a manual assignment method is recommended for assigning learning phase categories.

The preliminary media selection model design includes:

(1) a decision aid that will assist the user in selecting the most appropriate media selection model;

(2) a data set development capability that will permit the tailoring and management of the behavioral statements to be analyzed;

(3) a media selection model development function that will provide for the entry of a new media selection model or the modification of a model already in the system; and

(4) a media selection model application function that includes model selection, behavioral statement assignment, initial media determination, training system alternatives determination, final media selection, media results clustering, and course media requirements determination.

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NOTE: This media analysis has been performed by Dynamics Research Corporation, Andover, MA as part of the Training Systems for Maintenance (TRANSFORM), a USAF Armstrong Laboratory program, and as part of the Joint Service Instructional Systems Development/Logistic Support Analysis Decision Support System (JS ISD/LSAR DSS), an Office of the Assistant Secretary of Defense sponsored program. Both programs have been developed for the DoD by Dynamics Research Corporation.

CD-ROM: A Delivery Medium for CBT!

Allen L. Luettgen, F. Kay Houghton, and Andrew E. Andrews

Computer-based training (CBT) development has evolved fromelectronic page turners to a sophisticated instructional environment. The use of numerous large image files, large digital audio files, and complex computer-generated graphics files places great demands on a system's capacity for binary storage (disk space). One solution is the use of compact disc-read only memory (CD-ROM).

The explosive growth of CD-ROM players in the marketplace makes CD-ROM a viable delivery medium for CBT. Recently, a CBT package for radiation protection technicians (RPTs) at Los Alamos National Laboratory (LANL) was produced on CD- ROM. The course is delivered on a multimedia system consisting of the following: MS DOS-based computer, CD-ROM player, high-resolution video graphics array (VGA) monitor, scanned color images with graphic overlays, digital audio, and mouse interface.

This paper will allow the reader to assess the appropriateness of CD-ROM for a specific project, report on lessons learned from the RPT project, demonstrate that CD- ROM is within reach of the average CBT developer, and provide guidelines for successfully developing CD-ROM based CBT. This paper can serve as a basic primer on how to adapt CD-ROM as a CBT medium. Some of the technical aspects that are discussed are listed here: CD-ROM basics for CBT development, availability of low-cost development environments, file organization, optimization of CD-ROM response times, effective use of digital audio and still frame graphics, and animation with CD-ROM.

CD-ROM can make complex CBT possible in an affordable environment. By creatively incorporating scanned images, large computer-generated graphics, and digital audio, one can avoid the expense and limitations of the video disc technology.

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CD-ROM: A DELIVERY MEDIUM FOR CBT!

Allen L. Luettgen, Kay Houghton, and Andrew E. Andrews

Introduction Computer-based training (CBT) development has evolved from electronic page turners to a sophisticated instructional environment. Today, CBT packages can incorporate scanned images, large computer-generated graphics, and digital audio. The use of numerous large image files, large digital audio files, and complex computer-generated graphics files places great demands on a system's capacity for binary storage (disk space). When using interactive video disc is prohibitive because of cost, availability of delivery systems, or inadequate distribution systems, alternative media are required. One possibility is compact disc-read only memory (CD-ROM).

The explosive growth of CD-ROM players in the marketplace makes CD-ROM a viable delivery medium for CBT. Recently, a CBT package for radiation protection technicians (RPTs) at Los Alamos National Laboratory (LANL) was produced on CD-ROM, and the course is delivered on a multimedia system.

This paper will allow the reader to assess the appropriateness of CD-ROM for a specific project, report on lessons learned from the RPT project, demonstrate that CD-ROM is within reach of the average CBT developer, and provide guidelines for successfully developing CD-ROM-based CBT.

Why CD-ROM For many reasons, CD-ROM should be considered for the development of CBT. CD-ROM can make complex CBT possible in an affordable environment. The robustness of CD-ROM allows a person to creatively incorporate scanned images, large computer-generated graphics, and digital audio into training and learning applications. Also, the large storage capacity of the CD-ROM will allow it to play a vital role in future CBT and learning applications.

Cost In the last five years, the cost of CD-ROM production and development has decreased so that is within the reach of many training organizations. CD-ROM is now a cost-effective delivery vehicle for CBT. When considering the use of CD-ROM for CBT delivery, one should consider the costs of development and production.

Production Costs The cost of CD-ROM production includes the following items: development system equipment, delivery system equipment, and mastering or production of the CD-ROM. The equipment requirements for the delivery system and the development system are different. Because the development system requirements are dependent on the delivery system requirements, we will discuss the delivery system requirements first.

Several technology options must be considered when deriving the specifications of the delivery system. The first technology consideration is the selection of the delivery platform, which is based on cost, availability, and performance considerations. A bare-bones 80386 PC system, which costs less than $1,200, was determined to be the most appropriate platform for the RPT Trainer. A less capable machine is not recommended because of the performance limitations of the CD-ROM unit. The faster data transfer rates of the 80386 reduces the amount of time it takes to move the data from the MS-DOS(TM) buffers to program memory, thus allowing the CD-ROM to transfer data at its maximum capacity.

Another consideration is the use of color displays. Because the cost of color and

monochrome presentations is virtually the same, the decision to use color or monochrome should be based on CBT design considerations. Because there is little difference in cost, we recommend using color displays that allow both color graphics and scanned images.

Most CBT projects include the use of graphics, and the cost of adding graphics to the delivery system is negligible. Virtually all display boards have graphics capabilities. Furthermore, improvements in technology have made the cost/performance relationship between Video Graphics Array (VGA) and older standards comparable. With comparable cost/performance ratios, VGA is strongly recommended.

One of the most important features of a CBT project is the user interface. Several options are available for an input pointing device. The mouse is quickly becoming the preferred pointing device. Nevertheless, light pens and touch screens are available options but are not directly supported by VGA and require additional equipment, thus increasing the cost of the delivery system.

During the design of the CBT, a decision must be made to use audio or not. The cost of adding audio to a CBT depends on whether analog or digital audio is used. An analog system includes the tape player and the speakers; the price of an analog audio system starts at $50 and depends on the required fidelity. A digital audio system includes a digital audio board and speakers. The board we used, the DSA-320 audio board from OnLine, Inc.(TM), is about $400. Other boards and playback systems are advertised for less money, which indicates that the cost of digital audio boards is decreasing.

The CD-ROM player ($400 to $800) is required for a CD-ROM CBT. The International Standards Organization (ISO) adapted the ISO 9960 as the standard that defines a CD-ROM directory structure. Therefore, to ensure that the CD-ROM unit can read any CD-ROM disc, the unit should be able to read the ISO 9960 CD-ROM disc format.

Once the delivery system has been defined, the development system requirements can be derived from the delivery system. The development system specifications are those of the delivery system plus a read/write medium. Because a training project is revised numerous times before it is mastered, the development system needs to easily accommodate changes and yet simulate the CD-ROM, which requires a large read/write disc storage.

The expense of a read/write medium varies. Listed below are costs per megabyte of some selected media (Dataware, Inc., 1989):

removable hard disk	$15
fixed hard disk	$10
magneto-optical removable disk	$10

Of the three media listed, we recommend the magneto-optical removable disc because it has performance characteristics most similar to those of the CD-ROM.

The mastering costs of a CD-ROM include formatting the data to be mastered and the mastering expense. Formatted media, magneto-optical cartridge or 9-track tape are sent to the mastering company (3M). Using a magneto-optical disc is recommended because the production of a 9-track tape requires additional equipment. Dataware, Inc. (1989) estimates the cost of mastering a disc to be $1,500 and the cost of each disc to be about $2.

Development Costs As in all CBT development, the costs are directly proportional to the complexity and size of the training system (Gery, 1989). The

complexity includes the quality and quantity of graphics, text, and audio used, as well as the intricacy of the feedback branching structure. Fortunately, the CD-ROM can help reduce the costs of program management and maintenance.

The program management costs are reduced by the use of MS-DOS CD-ROM Extensions(TM) file structure. On the PC, the developer perceives this file structure to be a MS-DOS(TM) file system, which allows the use of directories and subdirectories. Using directories and subdirectories permits convenient program modularization and integration of the modules.

One of the main concerns of CBT development is the updating of the training material. CD-ROM file structure allows easy updating of individual files. Because CD-ROM is read-only, the maintenance of the training program is limited to the costs associated with mastering of a new CD-ROM (~$1,500) plus modification of the program.

Media Robustness_ A CD-ROM is difficult to copy, write protected, crash-resistant, large in capacity, an easy medium for delivery of CBT, and physically durable, making it a robust medium. Because of the volume of CD-ROM data, the CD-ROM is difficult to copy.

Write Protection Because the CD-ROM is a read-only device, it is impossible for anyone to change, intentionally or unintentionally, any data on the medium. The read-only characteristics of the CD-ROM have many benefits. For example, we delivered a CBT course on a traditional, magnetic hard disc to the U. S. Army . The students began adding unauthorized enhancements to the courseware. Several times the enhancements forced us to reinstall the entire courseware. Preventing the possibility of the students' modifying the courseware in any form helps ensure some training consistency.

Crash Resistant The medium is crash resistant because a mechanical head does not pass over media. The information is read when a movable mirror reflects a low-power laser onto the media, eliminating the possibility of a head crash on the media.

Large Capacity The large capacity, 640 Mbytes, of the CD-ROM allows an entire training package, or possibly several training packages, to be resident on a single optical disc instead of dozens or hundreds of floppy discs. Therefore, the requirement of transferring sections of the program to and from the hard disc is eliminated. Also, the large capacity reduces the amount of actual disc swapping required, thus reducing the chances of damaging the media.

Easy Delivery The CD-ROM disc is similar to a floppy disc because it is removable. The delivery is simplified because the CD-ROM requires only the insertion of a single disc instead of copying many floppy discs. In addition, the CD-ROM has a large data capacity; therefore, it is possible to include original source code and supplemental software when the system is distributed. This medium also eliminates the need for back-up copies because the original data cannot be corrupted by unintentionally overwriting the update disc.

Physically Durable The CD-ROM is physically a rather tough medium. It is composed of a vinyl-type material, which should not be touched by the user. If the user inadvertently touches the medium, it will not necessarily be destroyed. Even though it should be kept in an environment that is as dust free as possible, it can be operated in an office without any special precautions.

Future Applications The opportunities for future use of CD-ROM technology are very exciting. The potential for

storing information is almost boundless. With one CD-ROM disc containing approximately the same amount of data as 150,000 to 200,000 pages of text or 1,200 to 1,500 floppy discs (Bitter, 1988), the ability to have large instructional structures is possible. A few of the applications that can benefit from the use of CD-ROM are described below.

Hypertext The extensive use of hypertext structures is feasible due to the large capacity of the CD-ROM. Hypertext structures are based on nonlinear access of information. Instead of progressing through data in a step-by-step fashion, hypertext allows the user to jump from one segment to another. Hypertext can be roughly compared with reading a book and then using the index to locate more information. Hypertext allows the networking of many large structures.

Simulation-based Training Limited space has made the use of computer-based simulations in training packages difficult to write. To be realistic, simulations need to be dynamic, that is, respond to learner input in a sophisticated enough manner to consider the impact of an action on the total simulation system. To be effective, the simulation should contain as many variables as possible. As the simulated system grows and becomes more complex, the number of possible paths and outcomes increases dramatically (often factorially), and the large storage capacity of the CD-ROM allows the storage of these complex systems. Finally, incorporating simulation into CBT in a manner that fully leverages the benefits of the simulation requires a different CBT paradigm that again increases data storage demands (Spangenberg, 1989).

Available References The CD-ROM can easily incorporate manuals and other references that are available to the learner, allowing greater learner control with very little programming overhead. Often while performing a job, the employee uses manuals and references. The ability to access these manuals during training makes the training more realistic, which is especially important during performance-based training.

Intelligent Tutor The large capacity allows the program to contain a greater number of possible interactions. This capacity can be used in more sophisticated intelligent tutoring systems. A tutoring system based on artificial intelligence (AI) will be able to access a large data base of stored knowledge and make decisions based on that knowledge. Gary Bitter (1988) contends that in our lifetime intelligent tutoring systems will be able to identify students' weaknesses, evaluate their needs and then tutor the students. Therefore, the intelligent tutor can do even more, can evaluate the individual's learning style, and can tailor the lesson accordingly. However, as the capacity of the program grows, so does its size.

A Place in DVI World The CD-ROM has a place in the Digital Video Interactive (DVI) world. DVI converts analog audio and full motion video data into a digital form at a rate of 30 frames per second. A single frame is represented digitally by appropriately 750 kbytes of data. Compression techniques help reduce the amount of storage needed to generate a full motion sequence on a computer. Even with compression rates of 50 to 1, one second of video requires 450 kbytes of storage. Updates to a DVI database can entail tens to hundreds megabytes of data. The large data capacity of the CD-ROM makes it the medium of choice for DVI updates.

This paper does not advocate the adoption of DVI over interactive video disc (IVD). The issue of the need for full motion video in CBT is linked to instructional design and cost-benefit considerations. While the use of still frame graphics and digital audio (possible with CD-ROM) can be argued

as a cost-attractive alternative to IVD, comparing IVD with DVI is beyond the scope of this paper. It should be noted, however, that adoption of CD-ROM is an investment compatible with the DVI technology.

Training and learning applications are limited only by one's imagination, not by the storage capabilities of the system. Thus, CD-ROM is playing a significant role in charting the future of computer-based training.

Developing CBT for a CD-ROM The developmental process of a CBT for CD-ROM delivery is similar to developing CBT for hard disc delivery. However, during development, a person must consider the unique characteristics of the CD-ROM; that is, it is a read-only device with slower access time and has a larger capacity than that of a hard disc.

Authoring Languages During the development of the RPT Trainer, we used two different software methodologies for developing lessons. The first module was developed using the OASYS(TM) authoring system, and the second was developed using the high-level programming language Modula-2. Both modules were developed for CD-ROM production. As far as the CD-ROM was concerned, there was no advantage to either system. However, because a programming language allows more complex data structures and branching structures than an authoring tool, it is possible to exploit the large capacity of the CD-ROM more completely with the programming language.

Implications of a Read-Only Device Because a CD-ROM is a read-only device, files cannot be written to it. For example, student records must be kept on either the resident hard disc, a floppy disc, or a network file server, which can cause some problems for an authoring system.

Because a CD-ROM is a read-only device, multiple mastering during CBT development would be prohibitively expensive. A cost-effective alternative to multiple mastering is the simulation of a CD-ROM on a hard disc or a magneto-optical drive.

Hard disc simulation of the CD-ROM is not recommended for two reasons. First, if a hard disc is used, the data would have to be transferred to magnetic tape before mastering a CD-ROM. This step incurs an added expense for the magnetic tape equipment. Second, the performance characteristics of the hard disc and the CD-ROM are substantially different. The CD-ROM performance is significantly slow when compared with that of the hard disc.

A magneto-optical disc is a better simulator of a CD-ROM than a hard disc, and the capacity and performance of the magneto-optical disc is comparable to that of the CD-ROM. The magneto-optical cartridge has two sides; each side has half the capacity of that of a CD-ROM. If a removable magneto-optical disc is used, the cartridge can be sent to the mastering company, eliminating transferring the system to magnetic tape. As a point of comparison, when we compared the cost of magneto-optical disc with the cost of magnetic tape equipment, the cost was $5,000 versus $30,000. At $5,000 for a magneto-optical disc system, CD-ROM premastering is affordable.

Performance considerations When developing CBT for CD-ROM delivery, the performance of the CD-ROM needs to be taken into account. The slower access time and larger capacity are the two conditions that are unique to CD-ROM.

Slow Access Time The performance characteristics are defined in terms of the CD-ROM drive performance and the operational characteristics of the software driver interfacing to the CD-ROM drive.

The CD-ROM drive performance characteristics include the data transfer rates and access time. The data transfer rates are 150 kbytes/s sustained and 600 kbytes/s burst. Access time is 0.8 seconds for a full stroke seek. Seek time is the amount of time necessary to move the mirror of the laser beam to the correct position on the CD-ROM. An average stroke is one-third of a full stroke, thus requiring 0.5 seconds. The typical rotational speeds of a CD-ROM are 530 rpm at the innermost track with a constant linear velocity of 1.4 meters/s and 200 rpm at the outmost track with a constant linear velocity of 1.2 meters/s (Sony Corporation 1988).

The operational characteristics of the software driver interfacing to the CD-ROM drive can have a large impact on the drive performance. The software driver commands the mirror to move and read data from the disc. The position of the mirror after the read operation can greatly affect the overall performance of the next read. The MS-DOS CD-ROM Extensions(TM) leaves the mirror at the last seek/read position. The next seek/read will require only minimal mirror movement to read adjacent data.

Slower performance time of the CD-ROM could have a dramatic impact on disc-intensive simulations. To help alleviate most of this problem, two approaches are recommended. The first involves disc caching of the data, and the second is intelligent file organization on the disc.

Disc Caching of Data Disc caching of the data on a CD-ROM can be accomplished by two methods. The first method is quite simple. During installation of the software driver for the CD-ROM, one selects the largest possible buffer size allowed. The maximum size of the buffer is driver dependent, but generally it is 64 kbytes. This buffer is used as temporary storage of data from the CD-ROM. Sectors from the CD-ROM are read until the buffer is full, thus taking advantage of the maximum transfer rate. Only the data requested are transferred from the buffer to the program.

The second method requires the developer to buffer files from the CD-ROM into DOS memory before they are used. The developer must track the files buffered. This method requires a significant amount of programming overhead and inconvenience on the part of the developer. Therefore, this method should not be used unless absolutely necessary. However, this method may be required for disc-intensive simulations. Because this method is too difficult for the novice user, it should be implemented only by the experienced programmer.

File Organization The intelligent file organization is related to the operational characteristics of the software driver. If the driver is the MS DOS CD-ROM Extension(TM), then placing files into subdirectories and locating related subdirectories together on CD-ROM is recommended. Organizing files into subdirectories allows the mastering company to place all files of the subdirectory sequentially on the disc. Thus, minimum mirror movement (access time) is required to read subsequent data in this subdirectory. Specifying the order of files within a subdirectory increases performance minutely; therefore, the subdirectory specification is the lowest data placement specification required for the CD-ROM. Because CD-ROM has nearly constant linear velocity anywhere on the disc, placement of the subdirectories relative to the inner or outer tracks does not matter.

Lessons Learned Several lesson were learned during development of the RPT Trainer. This section deals with specific lessons learned with our hardware and software suites. These lessons included dealing with scanned graphics, teaching

techniques, working with audio, optimizing seek times of files, and working with a magneto-optical disc.

Digitized Images A scanned graphic is a picture that has been digitized into a computer representation; all graphics were bit map graphics. Digitized images consist of any type of picture not created with a paint package. Furthermore, these images could not be directly displayed by the VGA subsystem.

Digital Image Production The process of producing a digital image begins with capturing a picture from a video tape, a still photograph, or a live camera and then converting it to a displayable format. This process is described below.

Still Photograph Image Capture Still photographs are converted into a computer representation by a scanner. We used a color, 300-dot-per-in. Howtech(TM) scanner. The scanner places the digital representation into a file. The resolution of the captured picture is 512 x 512. The file format of the scanned picture is compatible with the TrueVision Targa-16(TM) image capture and display system. Because the output file format used the TrueVision Targa-16(TM) file format, the digital representation contained a maximum of 32,768 colors. We experienced no problems with the scanner during the courseware development.

Video Tape or Live Camera Image Capture A single video tape frame or a snapshot from a live camera is converted into a computer representation of the image by a capture and display system. We used the TrueVision Targa-16(TM) system, which places the digital representation of the image into a file. The resolution of the captured picture is 512 x 512, and the maximum number of colors is 32,768.

Because our VCR did not have still frame capability, the capturing of pictures from video tape was an arduous task. The technician had to use a trial and error method to capture the correct picture frame. We strongly recommend the use of a VCR with still frame capability.

Picture Conversion After the picture is captured from a still photograph, video tape, or live camera, it has to be converted into a format displayable by the VGA system, which means that the number of colors of the picture must be reduced. The VGA system is capable of displaying 16 colors in the 640 x 480 resolution mode. The instructional strategies used in the RPT Trainer further limited the number of available colors to 12. Thus, the conversion process entails converting the digital image with 32,768 colors into a picture containing only 12 colors.

Limitation of the VGA Standard A brief discussion of how pictures are drawn on the screen is required to understand the source of limitations of number of colors displayable on the screen. We will try to make this discussion as painless as possible.

Every picture uses the colors from a color map to draw itself on the screen (this is a requirement of VGA standard). A color map is a palette of colors, and the picture selects the most appropriate colors by defining the set of colors in the color map.

The VGA standard limits the number of colors allowed in the color palette and screen resolutions. (A screen resolution is the maximum number of dots in the horizontal and vertical direction. These dots are called pixels.) Our courseware used two different screen resolutions, 640 x 480 and 320 x 200 (height and width) pixels. Both screen resolutions fill the same area on the screen but the lower resolution (320 x 200) uses a pixel that is four times larger than the higher resolution pixel size.

The VGA standard states that the 320 x 200 resolution can use 256 colors and the 640 x 480 resolution can use only 16

colors. This standard is based on the capabilities and amount of RAM available on the VGA card. The baseline VGA card has 256 kbytes of RAM. In the 640 x 480 resolution mode, 4 bits (1/2 byte) are needed to define 16 colors (16 = 2 raised to the 4th power). Because each pixel needs only one-half byte, two pixels can be stored in a single byte. The amount of RAM needed to define a 640 x 480 picture with 16 colors, using 2 pixels per byte, is 153,600 bytes or 153.6 kbytes.

640 x 480 = 307,200 pixels per screen.

1 bytes = 2 pixels.

307,200 pixels x (1 byte/2 pixels) = 153,600 bytes (or 153.6 kbytes).

If 256 colors are used in a 640 x 480 resolution mode, 8 bits (1 byte) are needed to define 256 colors (256 = 2 raised to the 8th power). The amount of RAM needed to define a 640 x 480 picture with 256 colors, using 1 pixel per byte, is 307,200 bytes or 307.2 kbytes.

640 x 480 = 307,200 pixels per screen.

1 bytes = 1 pixels.

307,200 pixels x (1 byte/1 pixel) = 307,200 bytes (or 307.2 kbytes).

Hence, with only 256 kbytes of memory available on the standard VGA card, only pictures with 640 x 480 resolution with 16 colors are displayable. The fewer total number of pixels used (number of pixels wide times number of pixels high) in a picture, the grainier the picture appears. The use of more colors helps to visually compensate for increased graininess. As the detail of the picture being displayed increases, a higher screen resolution is required. Trade-offs have to be made among displayed detail, the color quality of the picture and using a VGA card with more memory. We generally used the higher resolution to display the picture because the detail of the picture was more important than color quality. Also, changing between screen resolutions causes a disconcerting flash on the monitor. The alternative of using a VGA card with 256 kbytes of RAM memory was not available to us.

Limitation Imposed by Learning Strategies Learning strategy limitations begin to tread on the choice of teaching techniques or styles. The most appropriate learning strategy will not be addressed in this paper, only the limitations imposed on the scanned graphics by our selected learning strategies technique will be described. We used a learning strategy based on learner control, which allows the learner to move freely from one part of the program to another. To accomplish this mobility, a command bar appeared on every screen. The command bar consisted of user options, such as repeat audio, help, exit, continue, and so on. For consistency, the command bar was displayed using the same three colors. Furthermore, each screen used the same background color, which imposed a limitation that every screen and every color map would contain the same four colors in the same positions of the color map. The limitation of fixing four of the available 16 colors significantly curtailed the flexibility. If 256 colors were used, the penalty imposed by the four fixed colors would have been insignificant. A 640 x 480 screen with 256 colors requires an image file of 307.2 kbytes, which would consume the capacity of a hard disc quickly, but almost 2,000 such images can be stored on a single CD-ROM.

Conversion Process The captured image contains 32,768 colors, far more then the VGA standard allows. The conversion process, which reduces the number of colors in the digital image representation to 16 or 256 colors, requires two steps. The first step uses

the commercial image conversion package TEGA(TM) from Videotex Systems to convert the 32,768 colors into 16 or 256 colors. After the picture is in a format compatible with the VGA standard, the four fixed colors are changed by a manual process.

During the manual process, the picture was displayed in a paint package, and the four least obtrusive colors were changed to the RPT Trainer "standard colors." Changing four colors out of 256 colors was an easy process, but changing four colors out of 16 colors required considerably more effort and a good eye. The digital image was then ready to be displayed as part of the RPT Trainer on the VGA screen.

Digital Image Enhancement The digital images used in the CBT greatly enhanced the training by allowing the student to easily visualize the equipment and locations. The VGA standard and the learning strategies imposed rather severe constraints on the digital images, and the conversion process involved far too much manual effort. To reduce the amount of effort required to convert digital images to a displayable format, some analysis of the conversion process was performed.

Analysis of Digital Image Conversion The majority of the effort expended and the loss of visual clarity occurred during the color reduction process. The conversion of the digital image from 32,678 colors to 16 by the commercial software introduced the largest visual impairment of the picture. After the software conversion, an inordinate amount of time and skill was required to change the four additional colors. The visual characteristics of the image were remarkably better when the number of colors was increased from 16 to 256, and the color reduction required for the command bar was easily accomplished. Some exploration of improved color content at higher resolutions began near the end of the project, but too late to impact the developmental process.

Enhanced Color Resolution Systems We investigated the use of the updated VGA standard (Super VGA) of 640 x 480 resolution with 256 colors because it is supported by all monitor vendors. A higher resolution was not explored because it would necessitate upgrading both the monitor and the graphics board. Because VGA monitors are analog monitors, the number of colors displayed is a function of only the graphics board.

Choosing the Super VGA with 640 x 480 and 256 colors would impose constraints only on the graphics board, which is the least expensive item in the video subsystem. Many commercially available graphics boards supporting this Super VGA resolution are available. One must be careful when specifying a graphics board because not all graphics boards can support this Super VGA resolution using a standard VGA monitor. We recommend that one selects a graphics board that supports this Super VGA resolution and requires the use of a standard VGA monitor. The VGA monitor standard horizontal sync rate is 31.64 kHz and the VGA standard vertical sync rate is 70.08 Hz.

Because this Super VGA resolution extension to the VGA standard is not a standard, the implementation from one graphics board to another differs. We found some similarities among these boards and developed a prototype graphics driver to demonstrate the interoperability among multiple graphics boards. Since this development work was completed, commercial drivers supporting multiple graphics boards have become available (such as PCX Programmer Toolkit[TM] from Genus Microprogramming [Genus Microprogramming, 1989]). The increased visual clarity and the ease of the developmental process are strong motivating factors in recommending the higher color resolution for all future projects. Almost all graphics boards are supporting the 640 x 480 x 256 resolution. Generally, if an upgrade is

required, the upgrade entails inserting video RAM chips onto the graphics board. This process requires low to modest technical abilities. Furthermore, the commercial conversion package TEGA(TM) and most paint packages support this Super VGA resolution.

Inability to Animate Bit Map Graphics One disadvantage of using bit-mapped pictures was the inability to animate large pictures. Large animations were impossible because of the time required to seek and read each segment from the CD-ROM. Also, the large animations were very slow and unrealistic. Hence, we could animate only small areas of the screen, such as the needle on an instrument. It should be noted that Intel Corps' DVI technology essentially is a full-screen animation process, but at greatly increased cost.

Audio The pairing of audio with text can greatly enhance student learning and retention (Buckner and McGrath, 1961). The audio can be a paraphrasing or additional information; simply reading the written text is not very interesting to the student or to the developer. Audible cues can be given to the student without forcing him to read the screen, which can reduce eyestrain. Furthermore, the use of audio can lower the reading comprehension level required of the training package. Digital audio has been used in several training programs. For example, American Express is using digital audio on CD-ROM to train telephone operators (Videodisc Monitor, 1990), and digital audio is used with the RPT Trainer at Los Alamos National Laboratory.

It is difficult for the average listener to differentiate between the two basic types of audio: analog and digital. Analog audio contains a continuous range of frequencies (tones) and amplitudes (volume). Examples of analog audio are records and traditional casette tapes. On the other hand, digital audio contains a discrete range of frequencies and/or amplitudes. This type of audio is represented by stereo system compact disks (CDs), which produce good quality sound.

Using audio with CBT requires the user or system to synchronize the audio to the CBT. If the user is responsible for synchronizing the audio to the CBT, the user must interact with the audio system. Generally, this procedure involves turning on and off an analog tape player. The system can also turn the tape player on and off for the user, which may require the CBT station to have another piece of equipment. If the CBT is updated, the audio tape must be updated in addition to updating the training software. If digital audio is used, it can be contained on the CD-ROM, thereby eliminating the need for an external tape player. Additionally, using digital audio on a CD-ROM permits random access to the audio segments, a feature not available in a linear tape mechanism. If a CD-ROM is used when the CBT is updated, only the CD-ROM will be updated.

Digital Audio Digital audio is a digital representation of the analog audio. The conversion of analog audio to digital audio is similar to the process used in creating CDs. The analog audio is sampled at specified time intervals and converted into a digital representation. When digital audio is played, the digital representation is converted into an analog form, which is then sent to the speaker.

The quality of the digital audio is determined by several factors. The output sound can only be as good as the sum of the worst elements in the production of the audio. The factors affecting the quality of the digital audio sound are the quality of the original recording, the device used to convert the analog audio into digital audio, the device used to convert the digital audio back to an analog form, and the speaker used to produce the audio.

The most important factor affecting the sound quality is the original recording. If the original recording is low quality, the rest of the system can do little to improve the quality of the sound. To improve a low-quality, original recording requires audio processing techniques, which are beyond the scope of this paper. Furthermore, varying amplitudes of the original recording can have adverse effects on the digital audio. However, some corrections can made during the digitizing process, but it is easier to record at a constant level.

The digitizing device affects the conversion of analog audio into a digital audio. The state of digitizing electronics is so good that this step introduces almost no distortion into the digital audio. The sampling rate of the analog signal can have a dramatic effect on the audio. The faster the sampling rate, the closer the digital representation is to the analog signal. As the sampling rate increases, the amount of digital data increases. Sampling rates at 4, 6, 8, 12 kbytes were available for the digital recording of the RPT Trainer. Each sampling rate allows different ranges of sound to be digitized. The limitations imposed on the dynamic sound ranges are tabulated below:

Sampling Rate per Second	**Digitized Audio Range**
4 kbytes	300 Hz to 2 kHz
6 kbytes	300 Hz to 3 kHz
8 kbytes	300 Hz to 4 kHz
12 kbytes	300 Hz to 6 kHz

We found that a sampling rate of 6 to 8 kbytes produced sufficient sound quality for RPT Trainer requirements, whereas lower sampling rates produced unacceptable sound quality. The 12-kbyte sampling rate produced high-quality sound but was deemed unnecessary for the project based on the sound requirements and the choice of a speaker.

The size of the audio file produced is dependent on the sampling rate. The lower sampling rate produced smaller files. Five seconds of audio sampled at 8 kbyte creates a file of approximately 44 kbytes. Additional file space is required in the cataloging process of the audio. A crude calculation will show that at an 8-kbyte sampling rate, over 18 hours of audio can be stored on a CD-ROM.

Varying output levels in audio were primarily due to the digitizing process. Therefore, care should be exercised to maintain a constant level of input audio when digitizing audio.

When the audio is played, the digital representation is converted to analog form, which is then sent to the speaker. The state of digitizing electronics is so good that this step produces almost no detrimental effect on digital audio. However, the speaker can have a dramatic effect on the sound produced. If the speaker reproduces the sound poorly, the rest of the system can do little to compensate for the speaker. The RPT Trainer used a headset speaker, which allowed a lower sampling rate.

Limitations Imposed by Digital Audio

The primary limitation of digital audio is that it is a "memory hog." The higher the sound quality of the audio, the more disc space is required. The sound quality desired should be evaluated at the beginning of every project, and different levels of sound quality can be intermixed in a CBT.

The large capacity of the CD-ROM minimizes the impact of the memory requirements for digital audio. Because of the access speed, we discovered that

short audio sequences flowed into the program much better than did the long sequences. The attention span of the learner is another reason to keep the audio sequences relatively short. The quality of the digital audio was not affected by the CD-ROM, and there was no decrease in the clarity of the speech.

File Organization Optimization The slower access time of the CD-ROM was a major concern in the development of the CBT file system. The CBT design uses a large number of small external files, and we were concerned about the time needed to open and close these files. However, we observed very little delay on the PC 80386 machine. We organized the files on the CD-ROM to optimize the access time by creating separate subdirectories for large picture files, audio files, data files, and executable code, thus reducing the seek time to the large files. This optimization was easily accomplished.

CD-ROM Simulator As a technical note, we used an Advanced Graphic Applications (AGA) magneto-optical disc drive to simulate a CD-ROM. The AGA drive uses a two-sided cartridge with 320 Mbytes on each side. To access data on the other side of the optical disc requires removing the disc and flipping it over. The use of the AGA drive imposed some limitations during the development process. One limitation, however, was the number of allowable DOS buffers. The AGA software requires a patch DOS to version 3.3, which increases the size of each buffer from 512 bytes to 8192 bytes. If the program requires a large number of buffers, there may not be enough memory left to load and execute the program. Because the RPT Trainer did not need many buffers, we were able to reduce the number of buffers in the config.sys file to five.

Conclusions CD-ROM is a viable alternative for multimedia CBT delivery. Its large capacity allows the user to incorporate scanned images, large computer-generated graphics, and digital audio in a large CBT program. Once set up, the development for the CD-ROM is nearly identical to the development process for traditional delivery systems. Because the technical aspects of CBT development for CD-ROM are trivial, anyone who produces CBT courseware can deliver it on a CD-ROM, which enables CBT developers to maximize the time spent on courseware development.

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CREATING SOFTWARE TOOLS FOR ICW DEVELOPERS
(A SYSTEMS APPROACH)

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ABSTRACT

This paper focuses on the changing direction within the Air Training Command (ATC) Systems Support Activity (SSA) to meet the growing need for multiple software tools to support Interactive-courseware (ICW) development. In the past, the SSA's main function was to produce the Merlin authoring system. Now, with the emphasis on accomplishing more training "at the job site", more rapid course production is necessary. This requires shorter timelines, use of subject matter experts with little or no computer experience and the fielding of new courses quickly. This evolution drove ATC to rethink its philosophy regarding software tool development.

The purpose of this paper is two-fold:

1) detail the change in direction being taken by ATC and the SSA.
2) provide a description of tools; already produced, under development, or in the planning stage.

This paper is aimed at ICW developers at all levels of expertise. In fact, it was written in response to concerns voiced by subject matter experts with little knowledge of computer programming or software development who have been charged with producing ICW.

BIOGRAPHY

Capt Bill Coffey - is Chief, Customer Support Branch, 3302d Technical Training Squadron (ATC Systems Support Activity), Keesler AFB MS. His previous assignment was as Chief, Training Technology Plans Branch, 3400 Technical Training Wing (ATC), Lowry AFB CO. Captain Coffey holds a BS in Education from Oklahoma City University and an MA in Management Information Systems from Webster University. He has produced several ICW courses using the Merlin, Tencore, and Quest authoring tools and has helped design many of the tools we are now developing.

CREATING SOFTWARE TOOLS FOR ICW DEVELOPERS

(A SYSTEMS APPROACH)

INTRODUCTION

The production of high quality Interactive-courseware or ICW is often a time consuming and costly effort. For example; the learning curve for development of graphics and adequate testing strategies is often long and complex. It takes time for new developers to become proficient with the selected authoring tool. In addition, there are up front costs associated with purchasing the complete compliment of software required to do the job. Our goal is to provide novice developers with low cost, easy to use tools that reduce up front costs and shorten both the learning curve and development time.

One way to accomplish our goal - to give our developers the very best tools possible - is by taking a **systems approach** towards development. That is, we must field a complimentary suite of software products or, in other words a "software toolbox", that integrates all phases of ICW development into an easy to use package. Such tools provide the developer with "canned routines" or "preformatted shells" that only require the user to "fill in the blanks" to get the job done. By eliminating the need to manually produce lesson code, or use the "pixel by pixel" method for creating graphics, we enable the developers to concentrate on their most important task - educationally sound lesson design. We must also provide the necessary training on how to use these tools. Ideally, this training should be computer-based and accompany the products that we distribute.

In recognition of this fact, Air Training Command through its Systems Support Activity (SSA) located at Keesler AFB in Mississippi, is shifting its focus away from the production of a single authoring tool - MERLIN - in favor of developing several complimentary software tools to aid ICW developers. The SSA was selected for this role because it is the ATC focal point for all training related system development and life cycle support. Further, the SSA is undergoing a restructuring of its staff to balance the number of technical staff members with the number of training specialists. This is necessary to ensure that the tools developed by the SSA are geared toward the main target audience within the Air Force - subject matter experts with little or no computer programming experience.

In later paragraphs each of the following software tools will be discussed in greater detail:

A. GRAPHICS:

A graphics database program containing graphics available for use to decrease the amount of time a developer must spend in creating new graphics.

B. TEST ADMINISTRATOR:

A program to create, administer, and score tests. This program can also analyze test results when coupled with the Test Analysis or TAP package.

C. KEYBOARD TRAINER:

A basic typing tutorial aimed at non-proficient typists to help improve keyboard familiarity, speed and accuracy.

D. ARTS:

An Adaptive, Randomized Test Sequencer that provides a step-by-step format for writing objectives and test questions.

E. ACCD:

The Automated Course Control Documentation (ACCD) system is being developed to enable course developers (both ICW and non-ICW) to produce & update course documents.

F. MERLIN 3.2:

This is the non-IVD version of the Merlin Authoring tool. It is designed to run on a standard MS-DOS PC with 640k of RAM.

G. MERLIN 3.3:

An Interactive-video version of the MERLIN authoring tool. Specifically aimed at course developers who use the DVA-4000/ISA Board as their presentation media.

H. MERLIN FRONT-END:

A Graphical User Interface which negates the need for developers to write Merlin code. It offers pull down menus that enable a user to easily create a lesson.

BACKGROUND

According to the new Department of Defense Instruction (1322.20), for the Development and Management of ICW, dated March 14, 1991; "The

decision to use ICW shall be based on a comprehensive analysis of the total training system requirements, and a media selection analysis to determine if the use of ICW is an effective and efficient means for presenting training materials when compared with other potential training media."

There are many promising programs which cannot make it past this evaluation process due to cost and time constraints. Many of these programs could benefit training and in the long term prove to be very cost effective. However, they rely on costly methods for development (due to a lack of adequate software tools), and must use off-the-shelf authoring packages which often price the program out of the range where it is cost effective.

In response to these user needs, the ATC SSA is now focusing on more "up-front" user involvement in developing ICW software tools. This means, that our users will have a greater voice in what tools we develop, how they are designed, and what changes in configuration will be allowed. By providing the user with more input during the development process, we can produce integrated tools in a more timely and cost effective way. The SSA has the organic capability to produce useful software tools which can be used by ICW developers to compress lengthy timelines thereby reducing development costs. When the time it takes to generate good ICW can be reduced, previously unsupported projects gain rapid approval for implementation. The end result is a tangible training benefit to the DoD.

The list of tools presented earlier represents the SSA's response to requirements presented to us by our customers; the ATC Training Centers, Air Force Major Commands, the Air National Guard and Reserve, and the other services. It is not a complete nor conclusive list but, rather an initial reply to the need for more efficient tools to aid ICW development. **What our users want is more training related functionality rather than more technical capabilities.** What users need to do their job effectively are software tools developed in response to training requirements and not software packages that force users to change their instructional design to match the design of the available software.

RESPONDING TO THE NEED

To meet the growing demand for easy to use, integrated software, the SSA is developing or maintaining the following tools:

A. GRAPHICS

One of the most time consuming tasks in ICW development is the production of graphics. In many cases the ICW organization does not have the talents of a graphics specialist available and this job falls to the "most qualified" person on the team. Normally, this results in less than professional products (which take an inordinate amount of time to produce) being used in the lessons. Several surveys were accomplished but, no government or off-the-shelf commercial package could be found that met the needs of our customers.

A graphics database program (written in 'C' and now being re-written in ADA) has been developed to decrease the amount of time a developer must spend in creating new graphics. This database already contains over 2000 PCX format graphics and is growing every day. It operates using a graphical interface and is very user friendly. The program (figure 1) allows a user to retrieve graphics by searching the entire database or, by the user entering from 1 to 4 keywords to narrow the search pattern.

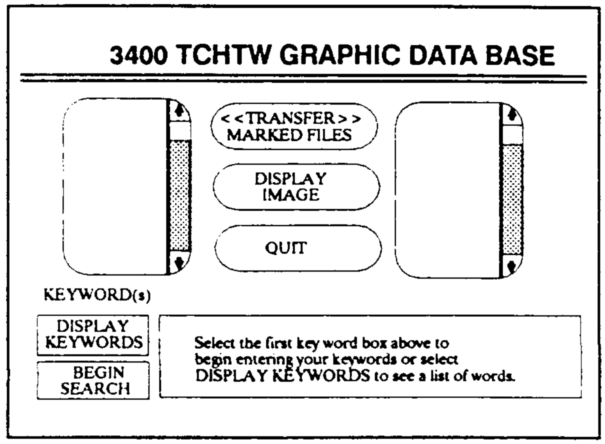

Figure 1 - MAIN GRAPHICS SCREEN

The database is alphabetized and can store as many graphics as there is system storage space. The user may elect to; view the graphics on the screen, copy the graphics to floppy disk, or copy the graphics to another directory location on the same computer containing the graphics database.

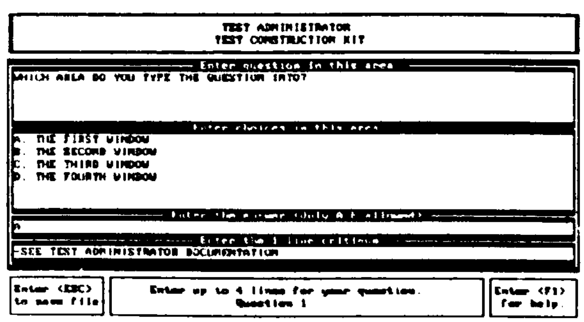

Figure 2 - PRIMARY TEST ADMINISTRATOR SCREEN

B. TEST ADMINISTRATOR

In response to a request from the USAF Personnel and Information Management Specialist Schools, the SSA created a program that enables a subject matter specialist to create, administer, and score tests. The program was written to allow instructors (even with no knowledge of the test file structure) to develop a test. Through the use of a simple menu system (figure 2), the instructor can develop a question pool and then administer and score the test.

C. KEYBOARD TRAINER:

Recognizing the fact that different people operate a keyboard, at various levels of proficiency, the SSA developed a basic typing tutorial to help improve keyboard familiarity, speed and accuracy. This product is a generic tool that has application for both beginner and advanced typist alike.

D. ARTS:

Randomized, adaptive testing refers to a relatively new instructional technology that is designed to decrease measurement error, while keeping test taking time to a minimum. ARTS was developed at Lowry Technical Training Center to meet the need for an adaptive and randomized test development and delivery system. The Adaptive, Randomized Test Sequencer provides a step-by-step tutorial on how to write objectives and test questions. It also provides for a "test pool" of questions that randomly selects questions to be presented at the time the test is taken.

ARTS consists of three integrated modules:

Module 1 - The ARTS Generator aids the developer in creating the test.

Module 2 - The ARTS Presentation randomly selects and presents the test.

Module 3 - The ARTS Report Generator compiles a record of student testing used by an instructor to obtain a breakdown of student performance.

ARTS Features:

The system can create a test pool which contains a maximum of 10 objectives with 15 possible questions for each objective or 150 total questions. Each question contains space for the correct answer and up to 4 distractors. The program can generate either multiple choice or true/false questions. A future version of ARTS will include the capability for matching and short answer. The randomization feature ensures that each student will be presented a different version of the test while making sure that all necessary objectives are tested.

(The minimum system configuration required to run ARTS is shown in figure 3.) ARTS uses four main menus or screens to "walk the user" through

SYSTEM REQUIREMENTS

MS-DOS computer.........IBM ST/AT or compatible
Minimum Memory...........640k required
Disk Drives.......................Floppy Disk drive
(Load and run ARTS from a hard disk drive if desired)
Monitor.............................Any model will suffice
MS-DOS...........................Version 2.0 or later

Figure 3 - ARTS SYSTEM REQUIREMENTS

the testing cycle. Each of these screens are shown below as figures 4 through 7

ADAPTIVE AND RANDOMIZED TEST SEQUENCER (ARTS)

TEST: cams1
OPR: terry l penna
DATE CREATED: 8 JAN 91
LAST DATE MODIFIED: 10 JAN 91
COMMENTS:
[cams introduction lesson pc]

NUMBER OF OBJECTIVES FOR THIS LESSON? [1]

F1 - Help Screen F3 - Load New Lesson File F5 - Delete Current Screen
F2 - Save to File F4 - Restore Current Screen F10 - Exit Program

Figure 4 - ARTS INITIAL DATA

ADAPTIVE AND RANDOMIZED TEST SEQUENCER (ARTS)

--- LESSON OBJECTIVE #2 ---

Number of questions to be presented? [15]
Maximum number of questions to be presented? [10]
Minimum percentage required for passing this objective?

F1 - Help Screen F3 - Load New Lesson File F5 - Delete Current Screen
F2 - Save to File F4 - Restore Current Screen F10 - Exit Program

Figure 5 - ARTS LESSON OBJECTIVES

Another important feature of ARTS is that it can be used with any Authoring System or Language which has the capability to "call external programs" such as DOS executables. This allows the developer

Student Name: GRAY

Student failed to pass one or more objectives

Objective number: 1

Identify facts, principles, and relationships associated with the Adaptive and Randomized Test Sequence system.

Student failed this objective

Question Presented	Student Response	Correct Answer
1	A	B
2	D	A

Figure 7 - ARTS TEST SUMMARY

ADAPTIVE AND RANDOMIZED TEST SEQUENCER (ARTS)

--- SUMMARY ---

TEST NAME: cams 1

OBJECTIVE	NUMBEROF QUESTIONS	MAXIMUM PRESENTED	% TO PASS
1	15	10	70

NUMBER OF OBJECTIVES: 1

OPR: terry 1 penna

DATE CREATED: 8 JAN 91

LAST DATE MODIFIED: 10 JAN 91

Press RETURN key to continue

Figure 6 - STUDENT SUMMARY

to use ARTS across a broad spectrum of media and keeps it independent from the authoring tool.

E. ACCD:

The Automated Course Control Documentation (ACCD) system is being developed to help course developers (ICW and non-ICW) to generate and quickly update the various documents used within a course. The program is being written to "issue flags" which alert the trainer that there are multiple documents affected each time they make a change to one of a series of related course documents.

F. MERLIN 3.2:

This version of Merlin is almost identical to version 3.3, except it does not contain the IVD capabilities.

G. MERLIN 3.3:

An Interactive-video version of the MERLIN authoring tool. Specifically aimed at course developers who use the DVA-4000/ISA Board to drive their presentation media.

H. MERLIN FRONT-END:

This program will enable a user to create Merlin lessons using a series of "preformatted templates" which negates the need to actually use Merlin code. It offers pull down menus that enable a user to easily create a lesson by following the menu structure (similar to a standard DOS tree structure) for each specific area. The menu system will allow a user to develop initial screen defaults for text, graphic, question, and branching functions. Once a user creates a default profile (say all positive question feedback is white text on cyan background) this default is carried through to all screens developed for questions and answers.

CONCLUSION

Within the Department of Defense, the pool of resources available for developing and conducting required training will most likely continue to shrink. There will be an ever increasing need to find new and more cost effective ways for meeting our training requirements. Also, it is quite evident that more training will be conducted at the user location using some form of exportable courseware. In general, this courseware will be ICW.

Subject Matter Specialiststs (SMSs) will continue to be the primary developers of ICW within the Air Force. They will require more sophisticated and perhaps more intelligent tools to aid them in their development efforts. It is not our aim to make "computer programming experts" of these SMSs. Our goal is to provide them with tools to automate functions so that the SMS can concentrate on the design and content of a course and not spend countless hours worrying about the technical details of production.

The ATC SSA will continue developing more software tools to help SMSs do their jobs. Additionally, we see our role evolving to encompass more training of users, more analysis of user requirements, and more hands-on development of ICW used to train people on how to use our products. **The keys to continued success are; user involvement in all phases of design and development, quality product support which includes training, and maintaining the systems approach to our efforts!**

ENDNOTES

1. ARTS and GRAPHICS were developed by 1Lts Doug Rausch and Steve Gray, 3400 Technical Training Wing (ATC), Lowry AFB, CO.
2. The DVA-4000/ISA Board is a proprietary piece of hardware produced by Video Logic Limited.

USER

SUPPORTING THE ISD-LSA INTERFACE WITH A CALS-COMPLIANT DATA INTERFACE

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ABSTRACT

This paper describes the design and implementation of an automated data interface supporting the concurrent Logistic Support Analysis (LSA) and Instructional Systems Development (ISD) processes. The Department of Defense (DoD) Computer-Aided Acquisition and Logistic Support (CALS) initiative requires the development of standard weapon system data bases that can be used to support front-end logistics, training, and performance analysis of new or emerging weapon systems. CALS includes the evolving concept of an Integrated Weapon System Data Base (IWSDB), a logical (as opposed to physical) collection of all data related to a weapon system's acquisition, design, operation, and support. Training analyses, as well as other LSA component processes, would have automated access to current weapon system data that are pertinent to training system development decision making. The CALS IWSDB requires standard definitions of data elements and data exchange standards that overcome inherent hardware/software incompatibilities. The ISD-LSA interface described in this paper depends upon standard definitions of training data elements and unique data exchange standards and procedures. The ISD-LSA CALS (Phase 1) interface described in this paper is accomplished through data exchange between an ISD analysis tool and the LSA Record (LSAR) within the CALS IWSDB. The structure of IWSDB (LSAR) input and output interchange data files are described. In addition to the data elements and relationships comprising the files, data control issues are addressed.

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The Joint Service ISD/LSAR DSS

The Joint Service Instructional Systems Development/Logistic Support Analysis Record (ISD/LSAR) Decision Support System (DSS) is a major Department of Defense (DoD) effort to better support ISD decision making and to integrate training system development with other weapon system design activities. The PC-based multi-user system consists of data input, ISD analysis, and training system design procedures that reflect and accommodate service-specific ISD methodologies.

The key feature of the Joint Service ISD/LSAR DSS is the automated LSAR-to-ISD data interface. The interface permits a training system development to maintain concurrency with the evolving weapon system design and supportability characteristics recorded in the LSAR. The decision support techniques employed by the DSS improve and standardize ISD decision making by providing users with appropriate and consistent presentations of LSAR and other training-related data.

The DSS consists of LSAR data input routines and Joint Service ISD analysis processes. The system includes utility functions that provide system security, database administration, report generation, and ISD analysis functions. The DSS automated procedures are presented in Figure 1 and consist of the following:

- ISD/LSAR Data Interface Functions
- Administrative Functions including data security
- ISD Program Management Functions
- ISD Analysis Procedures
- Select Tasks for Training, using the following models:
  - Sub-Task Analysis Model (STAM) for Task Selection
  - 8-Factor Model
  - 4-Factor Model
  - Difficulty, Importance, and Frequency (DIF) Model
  - Early Comparability Analysis (ECA) Model
- Select Instructional Settings
- Develop Learning Objectives
- Determine Instructional Sequence/ Develop Course Structures
- Select Training Media, using the following models:
  - Sub-Task Analysis Model (STAM) for Media Selection
  - Automated Instructional Media Selection (AIMS) Model
- Identify Fidelity Requirements of Training Devices
- Identify Training Device Instructional Features

The Joint Service ISD/LSAR DSS LSAR interface improves the quality of information exchange between ISD analysts and system/equipment designers, providing the ability to address a wider range of training issues in a more complete fashion. Both the early analysis of training requirements and the systems engineering interaction with the equipment designers contribute to the development of more effective training systems.

LSAR Data Presentations

One of the unique features of the Joint Service ISD/LSAR DSS is its interface with LSAR data. Meaningful presentations of LSAR training-related data support the analyst in performing ISD analyses and in making effective ISD decisions. The DSS uses LSAR data in one of two ways. First, LSAR data that describe a weapon system's equipment structure, task hierarchy,

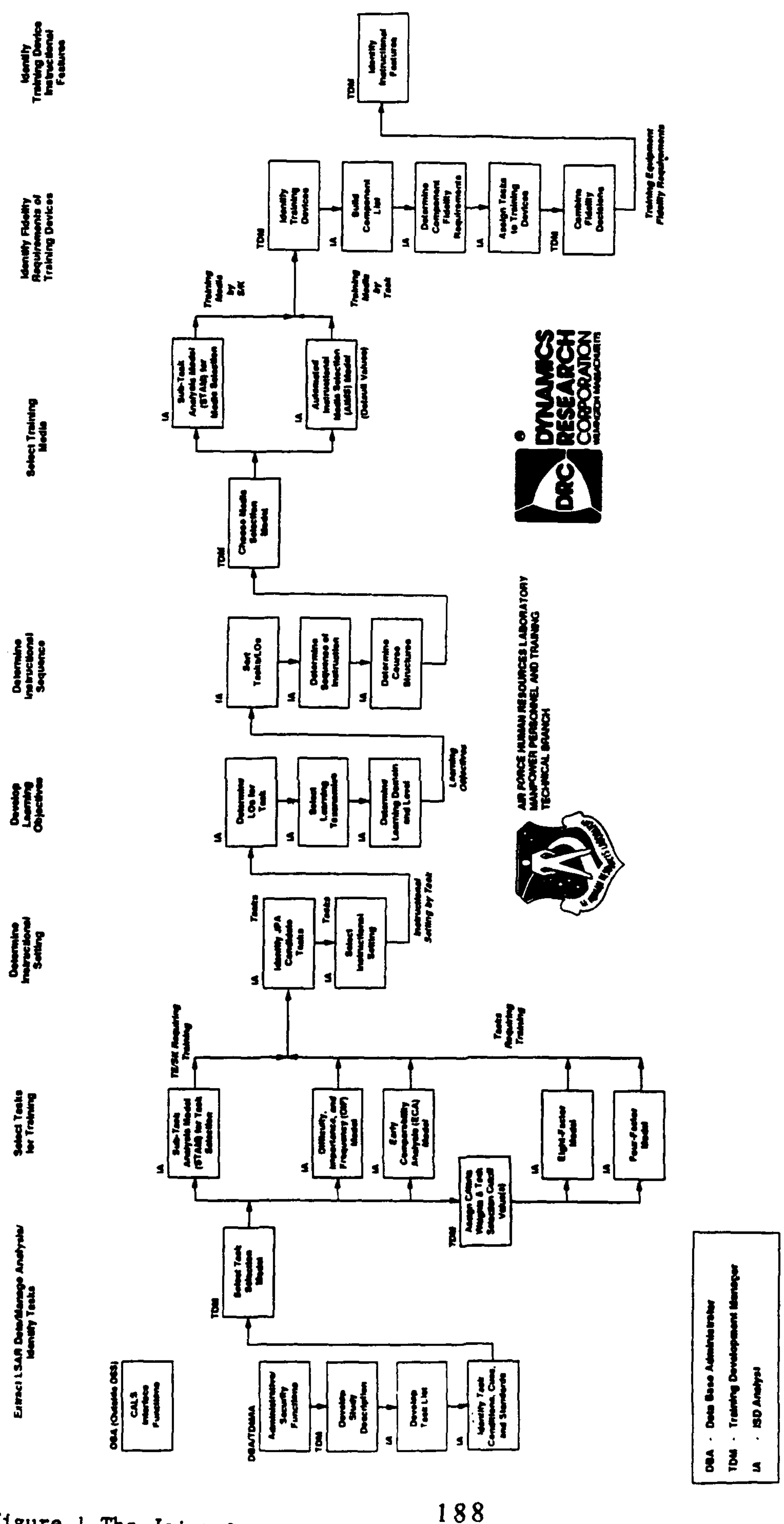

Figure 1 The Joint Service ISD/LSAR DSS

Table I LSAR Data Elements in the DSS Data Set

May 1990 Draft MIL-STD-1388-2B		MIL-STD-1388-2A
Data Element Title	DED	DED
ALTERNATE LCN CODE	019	023
ANNUAL NUMBER OF MISSIONS	021	027
ANNUAL OPERATING DAYS	022	028
ANNUAL OPERATING REQUIREMENTS	023	029
END ITEM ACRONYM CODE	093	106
HARDNESS CRITICAL PROCEDURES (HCP)	148	153
HAZARDOUS MAINTENANCE PROCEDURES CODE	151	155
LCN NOMENCLATURE	195	181
LSA CONTROL NUMBER (LCN)	193	197
MEAN ELAPSED TIME	217	220
MEAN MAN-MINUTES	219	223
MEAN MINUTE ELAPSED TIME	220	232
MEAN MISSION DURATION	221	234
MEANS OF DETECTION	230	242
MEASUREMENT BASE (MB)	231	244
OPERATIONAL REQUIREMENT INDICATOR	268	285
PERFORMANCE STANDARDS	280	313
FACILITIES TRAINING REQUIREMENT CODE	350A	394A
TRAINING EQUIPMENT REQUIREMENT CODE	350B	394B
TOOL/SUPPORT EQUIPMENT REQUIREMENTS CO	350C	394C
SEQUENTIAL SUBTASK DESCRIPTION	364	410
SKILL LEVEL CODE	378	422
SKILL SPECIALTY CODE (SSC)	379	423
SKILL SPECIALTY EVALUATION CODE	380	433
SUBTASK NUMBER	399	451
TASK CODE	419	467
TASK CONDITION	420	468
TASK CRITICALITY	421	469
TASK FREQUENCY	422	470
TASK IDENTIFICATION	423	472
TECHNICAL MANUAL CODE (TM CODE)	429	479
TRAINING LOCATION RATIONALE	456	502
TRAINING RATIONALE	457	503
TRAINING RECOMMENDATION	458	504
WORK AREA CODE	508	544

and task performance requirements provide the ISD analysis structure used by the DSS. The ISD analyst uses LSAR data to construct the DSS subsystem, task, task element, skill/knowledge hierarchy. The second purpose of LSAR data is to support specific ISD decisions.

The Joint Service ISD/LSAR DSS, Version 4.0 is compatible with data element definitions and relationships in MIL-STD-1388-2A, Logistic Support Analysis Record, 20 July 1984. It is desireable to have the DSS eventually conform to the emerging revision to the LSAR standard, MIL-STD-1388-2B. Both MIL-STDs prescribe the data element definitions, data field lengths, and data entry requirements for LSAR data. MIL-STD-1388-2A uses two LSAR master files: the LSA Control Number (LCN) Master File and the Task Narrative Master File. The May 1990 draft MIL-STD-1388-2B uses a relational table structure of functional data element groupings, where MIL-STD-1388-2A consists of card images. Even though the new standard continues to evolve, most imported training data elements from -2A have been preserved in the -2B version with minor modifications. Table 1 provides a cross-reference of the training-related LSAR data elements from the two MIL-STDs that support DSS training analyses. The data elements are listed by both MIL-STD-1388-2A and MIL-STD-1388-2B (May 1990 draft) data element definition (DED) number.

The Joint Service ISD/LSAR DSS and CALS

The Department of Defense (DoD) Computer-Aided Acquisition and Logistic Support (CALS) initiative requires the development of standard weapon system data bases that can support front-end logistics, training, and performance analysis of new or emerging weapon systems. CALS includes the evolving concept of an Integrated Weapon System Data Base (IWSDB), a logical (as opposed to physical) collection of all data related to a Training analyses, as well as other LSA component processes, will have automated access to current weapon system data pertinent to training system development decision making.

New weapon system acquisition programs are being required to be "CALS compatible." Both industry and Government participants in many new system acquisitions are attempting to address CALS technical issues and realize the communication efficiencies and cost reductions expected from CALS compatibility. The effective use and exchange of weapon system design data in a CALS environment requires standard definitions of data elements and data exchange standards that overcome inherent incompatibilities between host hardware/software. The Joint Service ISD/LSAR DSS CALS interface depends upon standard definitions of training data elements and unique data exchange standards and procedures.

Operational Overview

Figure 2 presents an overview of the Joint Service ISD/LSAR DSS CALS (Phase 1) compatible automated LSAR-to-ISD data interface. The interface consists of several major data stores and data processes. The data stores depicted in Figure 2 reside either within the CALS IWSDB or the DSS tool. Each data store is described below:

Within the IWSDB:

LSAR Data - System/equipment logistics data maintained in accordance with MIL-STD-1388-2B.

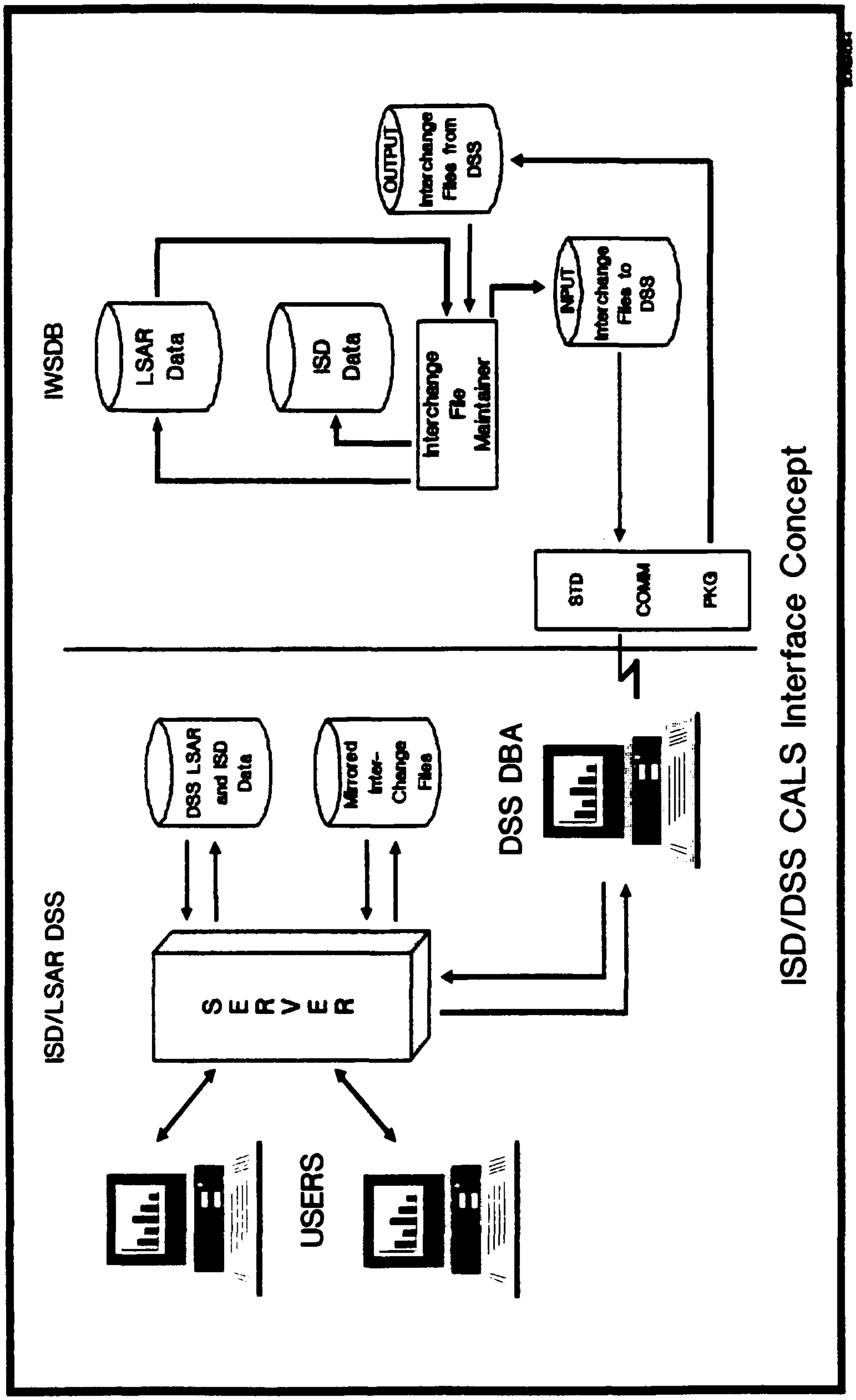

Figure 2 ISD/LSAR CALS Interface Concept

ISD Data - A logical store (corresponding to one or more physical stores) of training system-related data. The data may or may not also reside in the LSAR.

Input Interchange Files - The subset of LSAR data that is used to perform ISD analyses within the DSS.

Output Interchange Files - Data resulting from ISD analyses performed using the DSS. Data in this file include LSAR data elements, as well as data that can be used in other concurrent logistics and engineering processes.

Within the Joint Service ISD/LSAR DSS:

Mirrored Interchange Files - The complete or partial IWSDB interchange data files. The mirrored input files contain data awaiting analysis within the DSS; the mirrored output files contain data awaiting transmission to the IWSDB.

DSS LSAR and ISD Data - In-process LSAR and ISD data.

In addition to the above data stores, Figure 2 depicts three DSS CALS interface data processes, each described below:

Produce Input Interchange Files/Extract Data from Output Interchange Files - This is actually two data processes represented by the "Interchange File Maintainer" box in Figure 2. Creating the input interchange files requires the performance of LSAR data comparisons (detecting LSAR updates/changes).

Transfer Interchange Files - Represented in Figure 2 by the "STD COMM PKG" box, the transfer of interchange files between the IWSDB and the DSS is accomplished using the appropriate host-to-PC communications package (not part of the DSS).

Perform ISD Analyses/Produce Output Interchange Files - Performing ISD analyses using the DSS is unchanged by the CALS LSAR data interface. An additional output process now constructs the output interchange files from DSS analysis results.

CALS Interface Data Flow Process Descriptions

Figure 3 displays the ISD/LSAR DSS CALS interface in the form of a data flow diagram (DFD). The processes and data stores presented in Figure 3 and described below expand upon those discussed in the Operational Overview and displayed in Figure 2. The process descriptions indicate the users/activities that are responsible for process development/performance. Many processes can be performed by a variety of users/activities. The user/activity categories "LSAR owners" and "ISD data owners" indicate those activities that exercise control over the data integrity of the LSAR and ISD data stores (data bases) within the IWSDB. Only the "owners" of data bases within the IWSDB have the authority to write to the data base. Such authority may be delegated. (Note: There is no Process 004, Data Store D004, or Data Store D005.)

Process 001 - Produce Input Interchange Files - The LSAR "owner" produces the input interchange files. This activity consists of preparing the input files in accordance with the approved MIL-STD-1388-2B data definitions and structure, by extracting training-related data elements from the LSAR. In addition to producing the input interchange files, the LSAR "owner" has the responsibility of determining changes from the previous input interchange

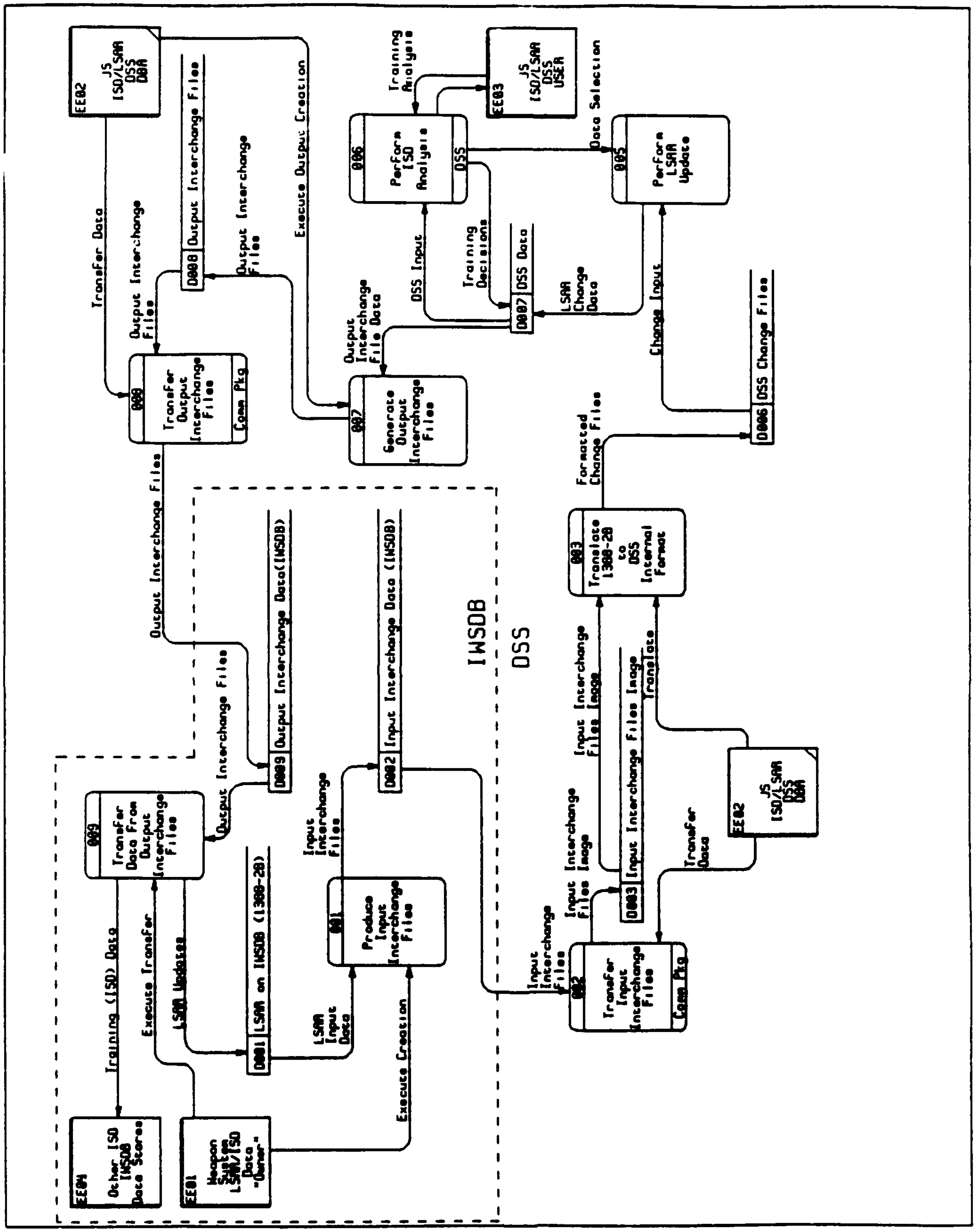

Figure 3. ISD/LSAR CALS Data Flow Diagram - Level 0

files. This function consists of identifying LSAR subsystem and task additions, changes, and deletions. This process will be redesigned upon final approval of MIL-STD-1388-2B. In the interim, the process has been developed for MIL-STD-1388-2A-defined LSAR data.

Process 002 - Transfer Input Interchange Files - The DSS Data Base Administrator (DBA) transmits the Input Interchange Data from the IWSDB to the DSS on the PC subsystem using a standard off-the-shelf communications package. In the absence of a communications procedure, data transfer can take place over an "air gap" using tapes or disks. The DBA transfers the data to hard disk storage in data store D003 - Input Interchange File Image, on the DSS PC subsystem.

Process 003 - Translate 1388-2B to DSS Internal Format - The MIL-STD-1388-2B to -2A translation of data elements only needs to be performed if MIL-STD-1388-2B data is feeding a 1388-2A-conforming DSS version. Process 003 will not be fully defined until the final MIL-STD-1388-2B is approved. The process creates data store D006 - DSS Change Files, and will be performed for the initial load of LSAR data and all subsequent updates.

Process 005 - Perform LSAR Update - This process takes place only if new LSAR data has been downloaded to update or append a previous download for a weapon system. Data from D006 - DSS Change Files, will be identified as additions, changes, and deletions in the DSS. Each addition, change, and deletion has been previously tagged within the IWSDB so that a DSS user will have the option of importing the new record into the analysis. The DSS DBA performs the initial LSAR data download. The DSS Training Development Manager and Subsystem Lead Analyst interacts with LSAR data updates by adding subsystems/tasks directly into the DSS, linking an LSAR addition to a user-created subsystem/task, and verifying changes and deletions.

Process 006 - Perform ISD Analysis - All DSS ISD analysts perform this process. Each analyst interacts with D007 - DSS Data (LSAR and other analysis data), to develop an equipment and task hierarchy. Analysts then determine training system requirements, supported by structured decision aids. Throughout the ISD analysis, iterative read/writes will take place with data store D007.

Process 007 - Generate Output Interchange Files - The DSS DBA performs the process of creating Output Interchange Files (Data Store D008, discussed below) through a standard DSS report option. The output format facilitates placement of DSS analysis results into the LSAR residing within the IWSDB (see Process 009).

Process 008 - Transfer Output Interchange Files - This process resembles process 002 - Transfer Input Interchange Output, but transmits data from the DSS to the IWSDB using a standard off-the-shelf communications package. In the absence of a communications procedures, data transfer can take place over an "air gap" using tapes or disks.

Process 009 - Transfer Data From Output Interchange Files - This process, like process 001 - Produce Input Interchange Files, takes place outside of the DSS. The actual interaction of the LSAR and ISD data "owners" and data stores D009 and D001 is uniquely defined by each user.

Data contained in the Output Interchange Files is provided to support other concurrent logistics and system engineering activities.

The following sections describe Joint Service ISD/LSAR DSS CALS interface data stores. The descriptions correspond to the data stores on Figure 3.

Data Store D001 - LSAR on IWSDB (1388-2B) - The approved MIL-STD-1388-2B will prescribe the data element definitions (DEDs), data field lengths, and formats for the LSAR. Government and contractor organizations will be required to adhere to the standard for all system/equipment acquisition programs, major modification programs, and applicable research and development projects through all phases of the system/equipment life cycle. The physical implementation of the MIL-STD-1388-2B LSAR data will vary widely among users. However, Government and contractor organizations will be capable of producing standard LSAR output reports. The Input Interchange Data (data store D002), required to feed LSAR data to the DSS, have been recommended for inclusion in the final MIL-STD-1388-2B as a standard output.

Data Store D002 - Input Interchange Data (IWSDB) - Training analyses using the DSS do not require LSAR data, but are most effective when fully supported by available LSAR data. Only training-related LSAR data elements are imported for ISD analyses using the DSS. The LSAR "owner" generates this data store for LSAR data transmittal to the DSS PC subsystem. The Input Interchange Data files are tentatively defined pending final approval of MIL-STD-1388-2B.

Data Store D003 - Input Interchange Files Image - This data store mirrors D002 - Input Interchange Data (IWSDB), described above. When D002 is transferred from the IWSDB, D003 exists within the DSS on the PC.

Data Store D006 - DSS Change Files - Within the DSS, D003 - Input Interchange Files Image, must be translated into a structure that conforms to the DSS data model (Process 003). The result is data store D006. Throughout an ISD analysis, the Training Development Manager and Subsystem Lead Analyst may access the additions, changes, and deletions as required. When exchanging LSAR data with the [MIL-STD-1388-2A conforming] DSS Version 4.0, D006 files are exactly the same as the existing LSAR update files. When the DSS is modified to conform with an approved MIL-STD-1388-2B, no translation is anticipated between the D003 - Input Interchange Files, and the D006 - DSS Change Files. D003 will be the direct input to the 1388-2B DSS, and Process 003 will be eliminated.

Data Store D007 - DSS Data - DSS Data is the collection of data residing in the Joint Service ISD/LSAR DSS. The data include LSAR data, inserted analysis administrative data, training system requirements decisions, and analysis working data. The DSS DBA, Training Development Manager, and ISD Analysts access this data store continually throughout an analysis.

Data Store D008 - Output Interchange Files - Output Interchange Files, consists of MIL-STD-1388-2B and MIL-STD-1379D data elements resulting from ISD analyses performed using the DSS. These data are for use by the LSAR "owner" and other concurrent logistics and engineering processes, thus supporting the intent of the DoD CALS initiatives.

Data Store D009 - Output Interchange Data (IWSDB) - This data store mirrors Data Store D008 - Output Interchange Files within the IWSDB.

CALS Interface Development Findings and Recommendations - To design an ISD-LSAR data interface that is both CALS compatible and operationally practical, user involvement in the design process was essential. The Joint Service ISD/LSAR DSS CALS interface design and operational concept were discussed at two Joint Service ISD/LSAR DSS CALS interface working group (IWG) meetings. The IWG meetings served as a forum in which expected users participated in the interface concept development and design. The IWGs took place on 23-24 May 1990 and 10-12 July 1990, in Washington, DC. A number of DSS CALS interface design and implementation issues were identified and discussed:

Issue #	
001	MIL-STD-1388-2B Status
002	Ongoing Evolution of CALS Training Data Element Definitions and Relationships
003	Input Interchange File Construction by LSAR "Owners"
004	Output Interchange File Review and Handling by LSAR and ISD Data "Owners"
005	Concurrent Government and Contractor/Sub-contractor Use of Interchange Files
006	LSAR Update Data Comparisons
007	CALS Interchange Data Concurrency
008	Data Translation from MIL-STD-1388-2B to DSS Format
009	September 1990 CALS Interface Demonstration
010	Ongoing ISD/LSAR DSS CALS Interface Information Exchange

Detailed discussions of each interface design/implementation issue are documented in the Joint Service ISD/LSAR DSS CALS Interface Requirements Report (Final). Dynamics Research Corporation, 31 July 1990.

Extensive user input on each CALS interface design/implementation issue resulted in an interface design that is responsive to needs of both Government and industry Joint Service ISD/LSAR DSS users. Moving beyond the limitations of a CALS (Phase 1) solution is a desired objective that will require additional work. Final approval of MIL-STD-1388-2B is a necessary prerequisite to a Joint Service ISD/LSAR DSS CALS (Phase 2) interface. The following three findings summarize the Joint Service ISD/LSAR DSS CALS interface development work performed to date:

Finding #1: An "evolving" MIL-STD-1388-2B (and other data element standards) will mandate the periodic revision of the architecture and/or the data interfaces of analysis tools that use data defined in the standard.

Finding #2: A CALS (Phase 2) LSAR data interface would overcome many of the inefficiencies and data integrity problems that exist in the Joint Service ISD/LSAR DSS CALS (Phase 1) interface. CALS (Phase 2) interfaces may ultimately prove to be unique arrangements of tools and data bases, rather than generalized solutions.

Finding #3: The ability to track LSAR data changes and assess their impacts on training system design is an attractive feature of the Joint Service ISD/LSAR DSS. The limited current capability could be expanded significantly with the use of MIL-STD-1388-2B data element date/time stamping or alternative schemes to track LSAR changes.

In response to the three findings, two general recommendations were made:

(1) Make the effort to get data element standards "right the first time." Balance any need to subsequently modify the standard with the cost and effort required to modify information systems that use the data.

(2) Use date/time stamping or alternate schemes to track data element changes in order to facilitate the efficient assessment of design changes on all related logistics processes and system engineering activities.

<u>Summary</u>

The Joint Service ISD/LSAR DSS is a powerful tool for performing ISD analyses of weapon systems. The automated capabilities eliminate labor-intensive data handling tasks and allow training analysts to effectively focus on the analysis of training system requirements. With its CALS compatible LSAR data interface, the Joint Service ISD/LSAR DSS offers many advantages over other ISD analysis methods. The CALS interface generates productivity improvements by including training system development in integrated product development/concurrent engineering. The effective use of available engineering/logistics data generates time and cost savings, improves decision making, and supports life cycle product improvements.

Instructional Systems Development Automation

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TSgt William E. Reid

The cold war has ended and a stable, democratic peace is spreading across the European continent. The Berlin Wall has come down, but another wall still remains--the wall of labor intensive instructional systems design. This wall blocks our objectivity and clouds our vision of true system training requirements. But we will vanquish the wall with our own olive branch process - Instructional Systems Development Automation.

Instructional Systems Development Automation (ISDA) is the name of the relational database program we have developed to address the dual problems of labor intensiveness and lack of standardized analysis parameter application.

ISDA addresses the first problem by eliminating repetitive data input, filtering out non-training requirements early in the analysis process, and automating report generation. The analyst inputs data from any source, i.e., LSA, technical manuals, etc. This information is broken down into sequential activities and analyzed. The software uses embedded decision logic to pull forward only those activities that require further analysis. The system generates a variety of reports, from task and duty lists to hardware and CBT fidelity analysis documentation. These reports had consumed a considerable amount of consolidation effort under the "paper" analysis methodology.

ISDA addresses the second problem by using embedded decision logic to assist the analyst in making training decisions. The system prompts the analyst with questions at the task activity, knowledge and skilled behavior, media, hardware, and CBT fidelity analysis levels. The analyst's answers to these questions provide the relevant information that the system uses to baseline decisions. The bottom line is that the system focuses the analysis and allows the Subject Matter Expert to develop straightforward, objective, training recommendations.

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MSgt Diel was a Training Systems Analyst with the 3306th Training Development Squadron at the time this paper was written. He is now the Assistant Director of the Edwards Air Force Base Family Support Center. He holds a Bachelor of Arts Degree in Liberal Arts.

TSgt Poteat is a Training Systems Analyst for the 3306th Training Development Squadron. He holds two Associate degrees: Avionics Technology and Instructor of Technology. He is our resident expert in applying ISD.

TSgt Reid is a Systems Analyst for the 3306th Training Development Squadron. Completely self-taught in computers, he wrote our ISD Automation software.

Instructional Systems Development Automation (ISDA)

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MSgt Eric L. Diel
TSgt Clarence W. Poteat
TSgt William E. Reid

INTRODUCTION

A significant part of the 3306th Training Development Squadron's mission is to determine maintenance training requirements for new or highly modified weapon systems. To this end we use a "tailored" approach to Instructional Systems Development (ISD). The model for this process was developed in 1979 by Applied Science Associates under contract to the Air Force Human Resources Laboratory (Now Armstrong Laboratory). Applied Science Associates delivered a closed 14 step model for front end analysis and ISD. The model has served the squadron and Air Force very well but it also has two inherent problems. The first problem is that the 14 step paper model is very labor intensive. It requires the analyst to document training decisions on a series of forms. The training decisions are transferred from document to document, creating a tremendous "paper trail" for each maintenance task under analysis. After several months of analysis this trail evolves into a pile of such proportions that it is almost impossible for the analyst to accurately update the analysis as new information becomes available. The second problem is one of application. The 14 step model involves decision algorithms. The analyst applies algorithms to the task under analysis and makes training recommendations based on the decision logic. The problem is that analysts don't apply the algorithms consistently. What is new to one may not be new to another. What seems to be hardware cues to one analyst may not be to another. The list goes on. These two problems started the 3306th on its development of ISDA.

PROCESS

The process has evolved from the original 14 step model, through a 13 step process, to the 15 step model that we have today. The following is a brief overview of each of the 15 steps.

Step 1 - Identify System Maintenance Requirements

In this step the analyst identifies all duties and tasks that must be performed to keep the weapon system operational. The analyst also gathers all relevant weapon system data.

Step 2 - Identify Characteristics of the Target Population

The analyst identifies the characteristics of the target population that could have a bearing on training requirements. Target population previous training, skills, knowledge, and experience are documented. This constitutes the analysis baseline and course entry prerequisites.

Step 3 - Determine Task Based Training Requirements

This step requires that the analyst break each task identified in Step 1 down into its specific activities. The analyst then measures the activities against specific criteria. If the activity meets any one or more of the analysis criteria, it is identified as a potential training requirement. All potential training requirements are carried forward for further analysis.

All non-training steps are flagged as "integrate", which means that they may be included in the training program but they won't drive any specific hardware or material requirements.

Those activities that drive potential training requirements are pulled into Behavior Analysis. In this sub-step the analyst breaks the activities down into component knowledges and behaviors. The knowledges and behaviors are then evaluated against specific analysis parameters. If the knowledge or behavior meets any one or more of the behavior analysis criteria, it becomes a firm training requirement. As soon as a specific knowledge or behavior is flagged as a training requirement, the analyst assigns a taxonomic code to categorize the type of learning that is going on.

Step 4 - Determine Concept Based Training Requirements

Step 3 required the analyst to identify all task specific training requirements. Many tasks require that the technician have prerequisite knowledge to be able to perform accurately. Fault isolation tasks, inspections, and operational checks are major categories that require the technician have a firm understanding of the concepts associated with the task performance requirement. This step is dedicated to determining those types of requirements. Tasks containing knowledge or skilled behavior training requirements that meet a specific taxonomic threshold are pulled forward for concept analysis. The analyst determines which concepts are associated with the task knowledge or skilled behavior training requirements. Once identified, the concepts are broken down into their elements. The elements are analyzed against specific criteria. If the element meets any one or more of the factors it is a potential training requirement. The potential concept element training requirements are subsequently broken down into their discrete characteristics. The characteristics are then analyzed against specific criteria. If the characteristic meets any of the analysis parameters, it must be trained.

Step 5 - Determine Media and Methodology

This step requires that the analyst identify a specific media class for each task knowledge, skilled behavior, and concept based training requirement identified in the previous steps. The analyst first determines the method of transmission for the instructional message. The analyst then determines the domain of learning that is being addressed. This leads the analyst into specific media analysis algorithms which assist the analyst in determining the appropriate media class for the behavioral or concept based training requirement. The media classes range from hardware to self-paced study guides. The analyst selects the method of instruction best suited to the specific media requirement.

Step 6 - Develop Instructional Strategies

In this step the analyst develops a criterion objective for each task or concept based training requirement. In addition, the analyst develops a criterion referenced test for each criterion objective. The analyst describes and links the training requirements to specific media descriptions. The analyst develops an instructional strategy that tells how the media will be employed to accomplish the criterion objective. The analyst sequences all task- and concept-based education and training requirements.

Step 7 - Identify Fidelity Requirements of Hardware Components

In Step 5 the analyst determines the classes of media that are required to support the training requirements. Step 7 requires that the analyst get very specific and identify the components and required fidelity levels for the hardware devices. To do this the SME will look at each of the behavioral training requirements that drive hardware. The analyst identifies the specific hardware components associated with the behavior. The analyst will then analyze the component against functional and physical fidelity algorithms. The purpose is to determine the level of fidelity (or realism) required to facilitate proper training and transfer. The analyst also determines "whole panel" fidelity requirements, which allows for maximum psychological fidelity in the training device.

Step 8 - Identify Fidelity Requirements of Comput-r Based Training (CBT)

During the media analysis that is performed in Step 5, the analyst might find that CBT is the appropriate media class for some of the training requirements. In Step 8 the analyst determines the required levels of fidelity for all training requirements that drive CBT. CBT can span the range of simple text based tutorial to high end interactive video with unlimited free play. The purpose of the step is to determine the most training effective CBT class to meet the requirement. The analyst will measure each behavior and concept characteristic that drove the CBT class against a CBT fidelity algorithm. The level of fidelity is determined as a result of the analysis.

Step 9 - Select Instructional Features

There are four aspects of any education or training scenario. They are: stimulus, response, feedback, and next activity. In the traditional instructor-led scenario, it's the instructor who supervises all four aspects. However, it's possible for hardware to be designed to control some or all of the training or education environment. This is why we determine instructional features for hardware media. The 3306th ISD process guides the analyst through two series of decision algorithms. The first series of algorithms is used to determine what should control the learning environment for specific hardware driving tasks. The analyst uses the second series of algorithms to determine the specific instructional feature requirements for all training requirements that the hardware training system should control.

Step 10 - Prepare ISD-Derived Training Equipment Specifications

The training equipment functional specification is the vehicle that conveys the weapon hardware training equipment and CBT (hardware only) requirements to the Program Office. The specification is a compilation of all analysis data and is organized into five major paragraphs. They are: Training Objectives, Training Application, Simulation Characteristics, Instructional Features, and Trainer Configuration.

Steps 11 Through 15

The remaining steps in the 3306th TDS ISD methodology are Step 11, Prepare Course Control Documents; Step 12, Prepare Instructional Materials; Step 13, Validate Instruction; Step 14, Conduct Training; and Step 15, Evaluate Training. The 3306th performs these steps as in the traditional five step ISD model.

PROGRAM STRUCTURE

The Instructional Systems Development Automation (ISDA) software is designed to automate the 3306th TDS ISD process through Step 11, Prepare Course Control Documents. The software is coded in Clipper, a relational database programming language. It will run on any IBM PC or compatible with 512K RAM and DOS 2.0 or higher. It will run from a floppy diskette but a hard drive is recommended because the data files grow very quickly. The program is built in 16 modules that basically mirror the 3306th ISD process. These are: Analysts, Duties, Target Population, Tasks, Activity Analysis, Knowledge/Skilled Behavior Analysis, Concepts, Element Analysis, Characteristic Analysis, Media Analysis, Instructional Strategies, Media Description, Sequencing, Hardware Fidelity, CBT Fidelity, and Instructional Features.

Analysts Module

The training manager or each analyst manually inputs the data pertaining to the analyst, and the respective weapon subsystem(s) that will require examination on the system. The analyst database provides identification data for the various reports in ISDA.

Duties Module

The analyst manually inputs the data pertaining to the specific duties the technician will be required to perform on the system. The analyst must build a duties database to start the analysis. The duty list focuses the analysis for the development task list that follows. The analysis proceeds as illustrated in Figure 1.

Target Population Module

The TARGET POPULATION module is similar to the previous modules in that the data is entered manually and no decisions are made by the system. The specific purpose of this module is to allow the analysts to enter specific information about their target audience. The goal is to focus the analysts' attention. Though the software does not use the information entered into this module for any specific decisions or actions, its significance cannot be taken for granted. Every training and education decision that the analyst will make in the following steps is based on the target audience.

Task Module

The TASK database follows the duty database. The task titles are entered manually. When building the task database the system requires the analyst to group tasks under the previously defined duties. The duties in essence become major categories of work or activity. The 3306th has found that this "structuring" of the analysis allows for a more logical and organized analysis.

Activity Analysis Module

The fourth module in the ISDA software is ACTIVITY ANALYSIS. This module draws in the previously identified tasks and prepares them for analysis. The analyst must manually enter each of the activities (also referred to as steps) that make up each task. Upon entering the activity, the system will open the activity analysis field. This is where the formal decision process leading to training and education requirement determination begins. This field contains the six parameters against which the analyst will measure the task activities. The parameters are: new, complex, condition, criteria, negative transfer, and tool/equipment. The software is designed to query the analyst with a series of "yes/no" type questions for each analysis parame-

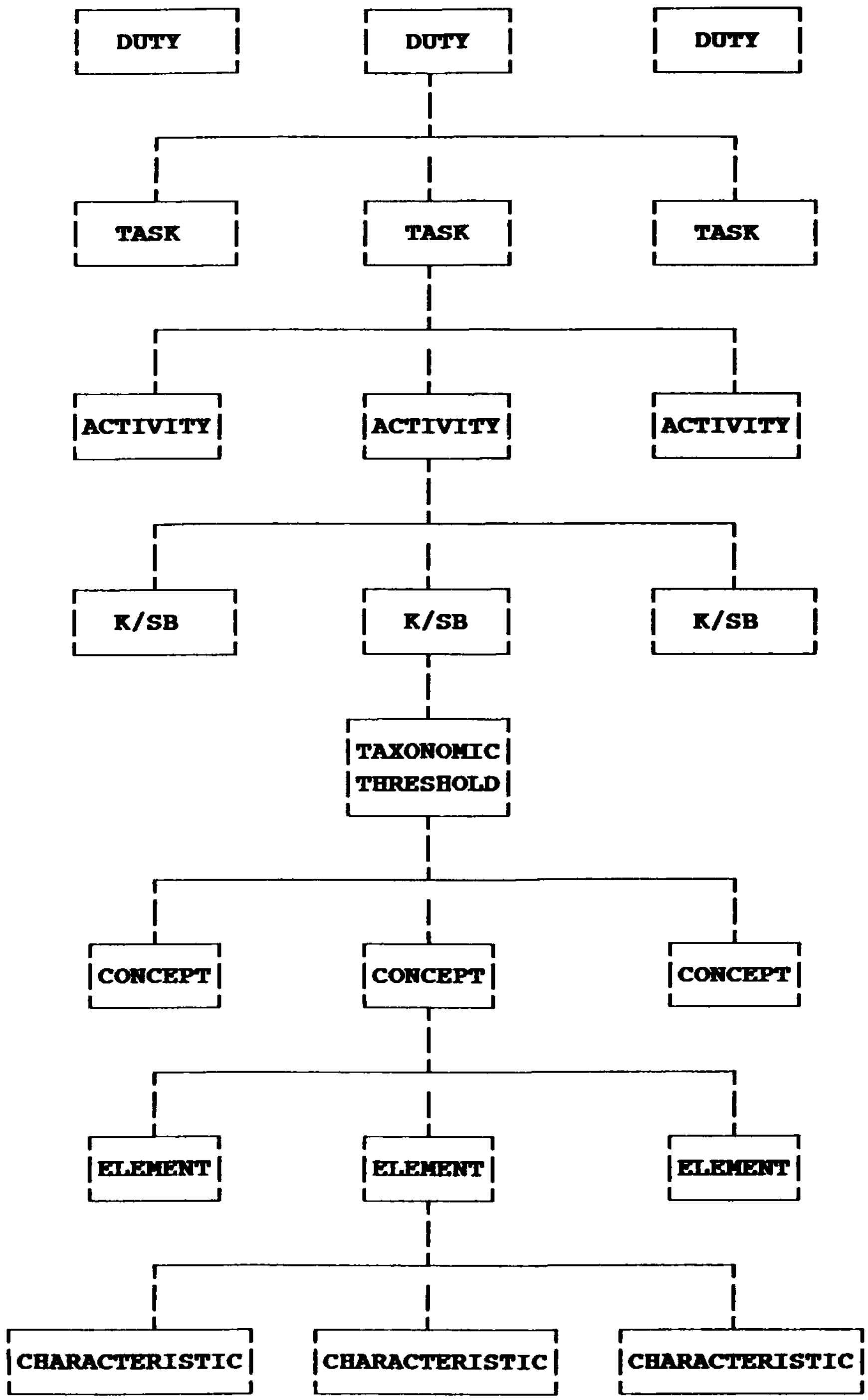

Figure 1 Analysis Hierarchy

ter. The questions are designed to determine if in fact a specific activity is new to the target population, if it is cognitively complex for the audience, if specific conditions that inhibit performance of psychomotor skills are present, etc. This allows the analyst to focus on performing as a subject matter expert and increases the objectivity and consistency of the recommendations. The ACTIVITY ANALYSIS module is also where the filtering of potential training requirements versus non-training requirements begins. If the analyst determines that none of the six analysis parameters applies to the activity, the activity is flagged "Integrate Only". This means that the item requires no further analysis. It won't be pulled forward into behavior analysis. Activities flagged as integrate can be included into a specific task training requirement if the analyst feels that they are required for task continuity or positive transfer. Integrated activities will not have any media resources dedicated specifically to them.

Knowledge/Skilled Behavior Analysis Module

The fifth module contains the code used to determine knowledge and skilled behavior training requirements. Each activity that is a potential training requirement is automatically pulled forward. The analyst determines, and manually inputs, the discrete knowledge and skilled behaviors that make up the activity. Each is analyzed against the same six analysis parameters used in activity analysis; the system queries the analyst to enhance objectivity. If a knowledge or skilled behavior falls out as true against one or more of the parameters, the system stores the unit as a training requirement. Finally, the analyst categorizes the training requirement by using a learning taxonomy classification. The system prompts the analyst for the taxonomy by providing a list of relevant action verbs for each taxonomy. The learning taxonomies used by the system, in hierarchal sequence are: Associating, Recalling Facts & Principles, Recalling Procedures, Repetitive Movement, Continuous Movement, Positioning & Serial Movement, Discriminating, Classifying, Rule Using, and Problem Solving.

Concept Analysis Module

Concept Analysis is directly linked to the previous task analysis module. This section is based on the theory that categories or levels of psychomotor activity require levels of understanding of specific concepts relating to the system.

ISDA determines if there is a potential requirement for concept analysis by scanning the previously completed task database and all of the corresponding task activity knowledge and skilled behavior training requirements. If any of the requirements meet the taxonomic threshold of classification the entire task is automatically pulled forward into the concept analysis database. The system then queries the analyst to determine if concept analysis must be performed for the task. If the analyst determines that concept analysis is required, the system will prompt for a concept title.

Element Analysis Module

Once entered, the analyst will break the concept down into specific elements. The elements are then analyzed against three analysis parameters: Relevant, Incidental, and Irrelevant. At this point, the analyst is determining potential training requirements in much the same way as was done previously in task activity level analysis. The

system prompts the analyst with a series of questions to determine where the element falls in regard to the analysis parameters. If an element is True against Relevant or Incidental, it drives a potential training requirement and will be pulled forward for further analysis.

Characteristics Analysis Module

The next step is for the analyst to break each potential element training requirement down into its discreet characteristics. The characteristics are units of information that are specific to the element, things that illustrate the element, make it easier to understand, or easier to apply on the job. The characteristics are analyzed against three analysis parameters: New, Complex, and Critical. The system will again prompt with a series of questions to aid the analyst in making this decision. If the characteristic is true against any of the three parameters it must be included in the training program. For those elements that require training, ISDA will go into media and method analysis. The media analysis decision logic for this portion of training requirements will be restricted to the tracks that pertain to the cognitive domain. This again increases the objectivity of the training decisions. The analyst can generate comprehensive reports of task and concept analyses that show training and non-training requirements, learning taxonomy classifications, and media requirements.

Media Analysis Module

Once a task knowledge, skilled behavior, or concept is established as a training requirement, ISDA requires that a specific media class and method of instruction be assigned to it. The media analysis code uses embedded decision logic that splits media analysis into six individual tracks. The appropriate track is based on whether the requirement is instructor or medium based and which domain of learning (cognitive, affective, psychomotor) the requirement resides in. The system again queries the analyst, and determines the appropriate media track, and ultimately the media class, based on the analyst's answers. The method of instruction is automatically entered by ISDA based on the media class.

Instructional Strategies Module

The system scans the databases for all tasks and concepts that contain either knowledges, skilled behaviors, or characteristics that contain training requirements. The software carries all related task or concept data (i.e. specific training requirements, media requirements, etc.) forward. The analyst selects a task from this list of trainable tasks. Then the system prompts the analyst for a learning behavior, and an instructional strategy for specific use of media. Finally, the system prompts the analyst for a teaching time. This is an estimate on the part of the analyst on how long it will take to teach and test the task or concept based training requirement. These figures are used to calculate lesson, block, and course training times.

Media Description Module

This portion of the analysis provides a detailed description of specific media requirements that allows the media developer to tailor specific media to specific requirements. The system will prompt the analyst for descriptions of each of the media classes identified previously in the Behavior or Characteristics Analysis modules. The system will have the analyst enter a description of specific media, and link the description to the knowledge, skilled behavior, or charac-

teristic training requirements with which it is associated.

Sequencing Module

This involves sequencing the training requirements into a course structure. The system will prompt the analyst to sequence the tasks and concepts to be trained into lessons. Then the system prompts the analyst to sequence the lessons into blocks. Finally, the blocks are sequenced into courses.

Hardware Fidelity Analysis Module

Once instructional strategies have been completed, the analyst can move into hardware fidelity analysis. The system scans all databases and draws forward those task activities, knowledges, and skilled behavioral training requirements that are flagged as requiring hardware. The system then asks the analyst to enter the names of the hardware components that the student must interface with during task training and performance. Once entered, the system will query the analyst for the required levels of functional and physical fidelity. The system bases the required fidelity levels on the analyst's responses. Once all primary hardware items have been identified and analyzed, the system asks the analyst to identify all "whole panel" components. These are components which students interface with indirectly. Surround components on a control panel, i.e, switches, lights, and bezels are examples of whole panel components. While not significant from a performance perspective, they are important to the psychological fidelity of the training system. By maximizing psychological fidelity as much as possible without overbuilding the trainer we enhance transfer out to the actual system. Once all components have been entered and analyzed at the task level, the system will build a database of all components and recommended fidelity levels. The system will show the results of this compilation to the analyst and ask if the level specified is satisfactory. If so, the analyst accepts the fidelity recommendation and moves on. If not, he can modify the final fidelity recommendation. The system will generate a complete list of all required hardware items that must be included on the training system and their required fidelity levels in table format that is ready for inclusion into the training equipment functional specification.

Computer Based Training Fidelity Analysis Module

The system is also designed to allow the analyst to perform Computer Based Training (CBT) fidelity analysis. This section is based on the fact that there are a variety of possible levels of CBT. They span the range from simple text based tutorials to fully interactive video simulations with numerous branching options. The level of the task or concept based training requirement determines the level of CBT that is most appropriate. The system will scan all previous analysis databases and build a new database containing all task or concept based training requirements that drive CBT. The system will show each task or concept and associated knowledges, skilled behaviors, elements, and characteristics that drove the CBT requirement. The system will then query the analyst using questions that deal with the type of learning and technical content of the material. The system takes this input and gives a recommendation on the level of CBT that would be most appropriate. The analyst can accept the recommendation or change it if circumstances warrant.

This portion of the program will generate a CBT fidelity report that can be used as a development guide

for the CBT courseware. By standardizing the logic that goes into making the decisions we achieve a more uniform approach to the courseware development effort.

Instructional Features Module

The final analysis module in ISDA deals with the selection of instructional features for the hardware training system. Traditional training scenarios have the instructor controlling the entire learning environment. Hardware training systems can be designed to address the stimulus, response, feedback, and next activity aspects of the training environment. They can be designed in such a way as to be transparent to the student and still provide the required level of control over the training situation. When the analyst enters into instructional features analysis the system will scan all existing data for those tasks that drive hardware. Those tasks are then entered by the system into the instructional features analysis database. The system brings each task up and asks the analyst to enter the appropriate task taxonomy. The system then asks a series of questions on each of the four learning aspects. The system makes instructional features recommendations based on the analyst's input. The system will generate an instructional features report that can be included into the training equipment functional specification.

CURRENT APPLICATIONS

ISDA has replaced the "paper" methodology. It is currently being used on the Joint Surveillance Target Attack Radar System (Joint STARS) and B-2 programs. Joint STARS was the first program to use ISDA for a weapon system training analysis. Many "growing pains" have been worked out during this implementation. In addition, the B-2 program is using the system to determine system training requirements for 3 level (semi-skilled) students. They are also collecting data to be used in a time savings study on this program versus the "paper" methodology.

The decision logic used in ISDA has also been incorporated into the Joint Service Logistic Support Analysis Record/Instructional Systems Development Decision Support System . This is a project sponsored by the Armstrong Laboratory aimed at automating the Logistics Support Analysis (LSA) data flow into the ISD process.

FUTURE DEVELOPMENTS

We are in the initial stages of developing algorithms that will aid in the selection of instructional strategies. Analysts are biased by what their experience has given them. In the traditional technical training environment, lecture/discussion and demonstration/performance have been the strategy of choice. The development of new media and methods of information transmission have broadened the scope of viable instructional strategies. The ultimate goal is to have the system query the analyst on areas such as target audience characteristics, type of material being taught, and potential learning problems. The system would then recommend a specific strategy based on the answers to the questions. In addition, we are working on processes that will aid in determining the instructional features requirements for CBT. We are focusing our efforts on a process that will aid in determining what features are required to address individual learning differences, what types of remediation are required, branching requirements, etc. We envision a system that will query the analyst (as done in CBT fidelity analysis) and ultimately recommend the CBT training strategy, branching, reme-

diation, and feedback routes that would best serve the student.

CONCLUSION

Instructional Systems Development Automation is proving itself to be a viable tool to aid an analyst in determining system maintenance training requirements. It greatly reduces the amount of administrative work that was put into the traditional analysis. Just as important, it standardizes the application of the analysis parameters and decision logic. The analysis is more objective and a better, more consistent set of training recommendations is the result. I have seen the future and its name is automation, probably sums up what ISDA is all about. We view the computer as a tool to aid the analyst in getting the job done. The more efficient we can make the tool and the processes that it interfaces with, the better the return on investment. We are not quite to the point where the system will ask the analyst to load the LSA data, press F10, and wait for the list of training requirements to come out, but give us some time.

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AN ADVANCED INSTRUCTIONAL DESIGN ADVISOR PROTOTYPE

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ABSTRACT

The Advanced Instructional Design Advisor (AIDA) project is an exploratory research and development effort at the Air Force Armstrong Laboratory's Human Resources Directorate (AL/HRTC). The purpose of AIDA is to establish the foundations for a set of intelligent and automated tools to assist military trainers in designing and developing effective computer-based instruction (CBI). The typical Air Force CBI developer is a subject matter expert with limited training in the use of computer-based technologies. Aggravating this lack of CBI design expertise is limited knowledge about how to optimize the use of CBI in various training settings.

AIDA is being designed to incorporate as much courseware design expertise as possible. The most promising technology available for this purpose involves the use of intelligent lesson templates, which have pre-established default values so that they are executable with minimal content input from a subject matter expert. This paper presents a detailed elaboration of intelligent templates and how they will be incorporated into AIDA. The discussion includes a description of several such templates and reports the results of the initial evaluation of two of these templates at the Air Force Academy and at the Lowry AFB Technical Training Center. In addition, we discuss the human factors issues involved in presenting design guidance to subject matter experts who have relatively little experience in instructional technology.

INTRODUCTION

Instructional design as a discipline has existed for at least forty years (Merrill, 1971). The traditional definition of instructional design is that it is the direct and practical application of knowledge about learning processes and tasks (Gagné, 1985). Over the years various learning theories and task analysis methodologies have provided the fuel for a number of instructional theories. At a very general level these various instructional theories share this common assumption: If you want to design effective instruction, then your instructional plans should take into account in-

formation about the tasks being trained as well as information about how students learn to perform a particular kind of task.

As with many disciplines, it is generally true in instructional design that the more time spent planning the less time spent implementing. This maxim has been largely ignored, however. When instruction is delivered by human instructors in a classroom setting, lack of carefully planned instruction can be compensated for by creative instructors. When information is not presented clearly to students, instructors are confronted with puzzled faces and confused responses. Experienced instructors can then present clarifications, answer questions, provide additional information, and so on, in a manner appropriate to the situation.

Using computers in educational or training situations complicates the process of instructional design. Computer software that is designed for instructional purposes is called courseware. Courseware that is not carefully designed and developed is likely to be both expensive and ineffective (Jonassen, 1988). Most courseware is delivered in settings without dedicated and experienced instructors present to react to student queries and problems. As a consequence, the need for very carefully planned instruction increases as more and more use is made of computer-based instruction (CBI).

More and more use of CBI should and will occur in the Air Force. Courseware can be used to raise the quality of training and education by providing review tutorials, drill and practice, meaningful simulations, and exploratory learning environments, all of which have proven learning value but might be too costly or labor intensive to provide by traditional means. In order to make effective use of CBI, it will be necessary to devise effective instructional design strategies appropriate for advanced computer-based instructional delivery settings.

THE PROBLEM ADDRESSED BY AIDA

The Air Force is confronting this problematic situation: 1) CBI is desirable for a variety of reasons in a variety of settings; 2) CBI can be expensive to produce -- estimates range from $10,000 per hour of CBI and up (Lippert, 1989); 3) There is a scarcity of expert knowledge about how to make optimal use of CBI. This situation is aggravated by the rapid development of advanced interactive technologies that have applications in CBI (e.g., DVI, a form of interactive digitized video) and by ever decreasing defense budgets.

AIDA is focusing on the design and development process (Spector, 1990). That process is notoriously time-consuming (Faiola, 1989). In addition, efficient development is hampered by the use of current authoring systems which require teams of experts and extensive testing and refinement in the development process (MacKnight & Balagopalan,

1989). In short, the Air Force needs more CBI (CBI is construed broadly to include all forms of computer-assisted instruction or CAI), but the Air Force cannot afford the expense of contracting out the development of CBI and lacks the expertise to produce effective CBI on a large scale basis.

THE PROPOSED SOLUTION

AIDA is intended to provide an automated and intelligent set of tools to assist subject matter experts in the creation of effective CBI (Muraida & Spector, 1990). AIDA will be a courseware authoring environment which advises and guides the user through the process of designing and developing CBI. The basic philosophy is to build into AIDA as much CBI design expertise as possible in order to enable subject matter experts with little background in instructional technology to develop effective CBI. The intent is to minimize the need for system specialists in the design and development process. AIDA will automate as much of this process as possible.

To accomplish this objective, AIDA will take established theories of knowledge, learning, and instruction and incorporate those theories into a meaningful course authoring environment. An extensive review of existing authoring environments indicates that none attempt to provide the kind of assistance and guidance to be available in AIDA (Hickey, Spector, & Muraida, 1990).

INTELLIGENT LESSON TEMPLATES

While some CBI developers have religiously applied traditional instructional systems design (ISD) methodologies to the design and development of courseware, others have concluded that radically improved methodologies are needed to guide the process of creating consistently effective CBI. Merrill and his colleagues at Utah State University have been developing transaction theory as part of a so-called second generation of instructional design (Merrill, Li, & Jones, 1990).

Merrill's transaction theory is based on the premise that CBI should be constructed around integrated computer-student interactions which involve all of the activities required to promote acquisition of mental models appropriate to mastering the task or subject of the instruction. Merrill and his colleagues have developed several demonstration transaction shells to illustrate the theory. Two of these have been loaned to the Armstrong Laboratory for purposes of evaluation: 1) Naming the parts, and 2) Checklist procedure.

These shells present the user with an interface that prompts for input of instructional content. The shell then constructs an executable student module using pre-established default values for relevant instructional parameters (e.g., number of items to include in a test, passing score, kinds of student interactions to allow, etc.). The user can alter the pre-established

default values and is likely to do so as experience with the system accrues.

As a consequence, it is fair to describe these transaction shells as intelligent lesson templates -- in a sense, a shell "knows" how its kind of instruction should be presented to students. AIDA will incorporate such templates and an intelligent front-end advisor to assist the user in determining which shells are best suited for a particular instructional purpose.

THE INITIAL EVALUATION

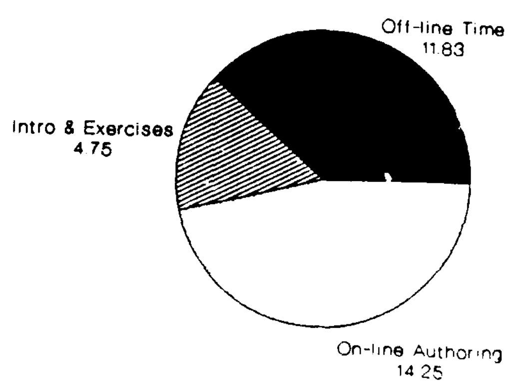
AL/HRTC performed the initial evaluation of the Naming Transaction Shell at the Air Force Academy in August, 1990 (Canfield & Spector, 1991). The purpose of this pilot study was twofold: 1) Determine how to conduct future evaluations of transaction shells, and 2) Make a preliminary assessment of the usability, productivity, accessibility, and generalizability of the Naming Transaction Shell.

A single subject was selected for the purpose of this study. He had only limited experience with computers -- knowledge of a word processor. He was an experienced instructor and had developed the course syllabus for the classroom-based course that was chosen for conversion to CBI. The course module to be developed concerned the names, functions, and locations of 125 instruments in the T-37 cockpit.

The subject was given about 5 hours of instruction on the use of the Naming Transaction Shell (see Figure 1). He spent about 12 hours planning the design and development of the course module. The subject was not responsible for creating graphical materials, but his planning time does include planning which graphics to include and what should be in the graphics. The subject spent about 14 hours online with the Naming Transaction Shell authoring, testing, and refining the module. In other words, the subject spent about half of the development on-line with the authoring system and about half off-line in a planning mode.

The net result of this 31 hour effort was a fairly sophisticated lesson composed of 10 separate modules nested in 3 layers using 20 individual picture files (see Figure 1). Student data is currently being collected, but it is expected that it will require in excess of 3 hours of student time to complete the lesson.

Figure 1. Development Hours



This means that the subject's development time to instruction time ratio was 31:3 or close to 10:1. A comparable development to instruction ratio using a traditional authoring tool (omitting time to develop graphics) would be about 200:1 (Lippert, 1989).

A follow-on study was conducted at Lowry AFB with eight subjects, all of whom were instructors at the Technical Training Center. Similar results were obtained. These subjects had little or no experience with CBI but were able to create meaningful and effective CBI lesson modules in just 30 hours. Student data was collected on one of the lessons to verify that the lessons were indeed effective. Additional evaluations with additional students and instructors are planned.

In short, the early indication is that using intelligent lesson templates or transaction shells is an extremely promising technology. While these situations were significantly constrained (e.g., rather simple but typical technical subject matter), two immediate conclusions are possible: 1) The transaction environment was accessible and easily learned by novice designers, and 2) Development time can be significantly reduced in many typical situations without sacrificing quality of CBI.

THE ARCHITECTURE OF AIDA

The implications of these studies for AIDA is significant. Based on the positive results just reported, it appears that AIDA should incorporate intelligent lesson templates into its architectural design. The current plan is to construct an AIDA prototype that contains a half dozen intelligent lesson templates. A minimal set probably includes the following:

1. Naming the parts (graphically based)

2. Checklist procedures (graphically based)

3. Teaching terminology (non-graphically based)

4. Classification/decision making (graphically based)

5. Building a scenario (video or animation based)

6. Simulation of a setting (video or animation based)

There are obviously other possible templates that could be included in the initial system (e.g., a template for generating practice problems). Whether less or more will actually be included in the first AIDA prototype will most likely depend on how much money is devoted to the next phase of the project. Each of these intelligent templates will be constructed so that it provided the following for the user:

1. An intuitive interface to allow easy input of instructional materials.

2. A set of pre-

established instructional parameters that are generally appropriate for the type of material normally used in that template.

3. A method for easy alteration of some of these parameters so that users could customize the delivery of selected instructional materials.

4. A help feature which provided online explanation of a particular item.

5. A student tryout mode to use in testing the lesson at various points during development.

6. A catalog of existing and possibly relevant files.

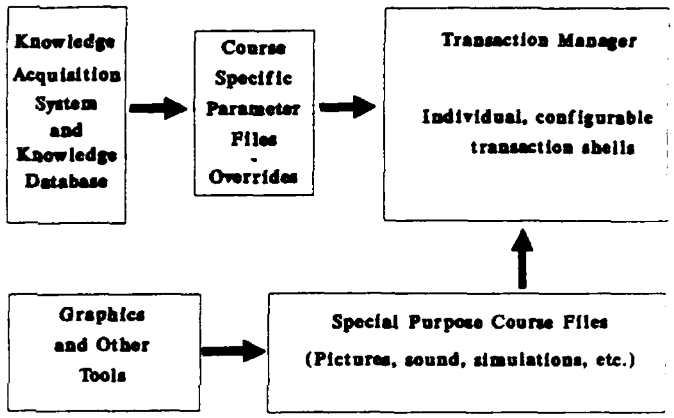
7. A method of advising users which template might be best suited to a particular instructional objective.

8. A method of advising users how they might consider altering some of the instructional parameters.

9. Data collection on students and instructors. Student data would be used by instructors to evaluated effectiveness of particular lesson materials. Instructor data would be used by system designers to refine future versions of AIDA.

The overall architecture of AIDA based on the use of intelligent lesson templates is depicted in Figure 2.

Figure 2. AIDA Architecture



CONCLUSION

AIDA promises to provide a productive CBI authoring environment that is accessible to those subject matter experts who have had virtually no previous experience with computers or with CBI. Merrill's transaction shells indicate that the use of intelligent lesson templates is an extremely promising technology with the potential to significantly reduce development times.

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ELECTRONIC STORYBOARD/DATABASE INTEGRATION: A KEY TO ACCELERATING THE IVD DEVELOPMENT PROCESS

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ABSTRACT

In the Computer-Based Training (CBT) development process, creating flowcharts and storyboards is both necessary and time consuming. On average, 40-50 percent of the total program development time is attributable to these two activities. However, when developing IVD, the courseware developer must also track video requirements specified on the storyboards. In high density, still frame applications, video requirements typically range from 15,000 to 100,000 separate video shots or sequences. The use of a database is essential for this process. In the past, courseware developers have, of necessity, manually generated storyboards from flowcharts and then manually inputted video requirements into the database. This procedure tended to be both time consuming and mistake prone. The Interactive Courseware Development Section of the 3300 Technical Training Wing has developed an automatic storyboard/database integration package which allows the courseware developer to electronically storyboard using WordPerfect and then integrate the data into dBase IV. This automated procedure has produced a significant decrease in development time, while reducing the human error factor when manipulating a massive amount of data.

BIOGRAPHY

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ELECTRONIC STORYBOARD/DATABASE INTEGRATION: A KEY TO ACCELERATING THE IVD DEVELOPMENT PROCESS

INTRODUCTION

Interactive videodisc (IVD) technology is now commonly being used in both military and industrial training. However, a common complaint of IVD is the development process is too lengthy and too expensive to produce a cost effective training media. A major factor in the length and expense of the development process is that the work of the instructional designer, subject matter expert, courseware developer, video producer, and computer programmer must all be combined to create a videodisc. Streamlining this data collection process, while being careful not to omit any step, will decrease the overall development time, and in turn reduce project costs. This paper will examine an electronic storyboard, developed using off-the-shelf application software combined with in-house customized software. This integrated package provides a detailed means of combining all team member inputs to the videodisc, while ensuring all steps in the development process are followed.

Solutions to the storyboarding problems are gradually becoming available in the form of computer software - especially integrated packages - that allow for the streamlining of the development process. However, for our environment, we needed a comprehensive electronic storyboard capable of being modified as various projects evolve. To this end, WordPerfect[1] was selected as the primary storyboarding tool because of its flexibility and capacity for developing and using macros (a group of user-defined instructions that can be activated together when needed[2]). To manipulate the data, a Database Management Information System was needed. dBase IV[3] was selected for this task. A major obstacle in developing the integrated storyboard package was the portability of the data from the WordPerfect format into dBase IV. Members of the 3302 Technical Training Squadron (System Support Activity(SSA)) developed a customized software program that will accomplish this data transfer. Through a series of menus, courseware developers can readily obtain access, use the integrated package, and store all necessary information pertaining to each project.

WORDPERFECT

Aside from the comprehensive wordprocessing capabilities of WordPerfect, this software package provides a macro feature that includes the flexibility of a programming language. Using the macro editor, we were able to create various macros and nested macros, that not only automate the storyboard, but provide prompts and help routines that an inexperienced user could easily use.

This automation provides multiple advantages in the IVD development process: firstly, it eliminates the need for a paper-based storyboarding system. Besides saving paper and storage space that would be required for a paper-based system, all project data is maintained by the computer and easily located or changed as the project evolves. Secondly, all storyboard development efforts become standardized. No longer are various team members using storyboard conventions that are not standardized within the project team. Thirdly, all members of the development team are able to utilize the same database to manipulate the data at will. For example, items such as shotlists, scripts, graphic lists, program text, and programming instructions are produced with little effort. Fourthly, the development process time has been shortened. The developer can copy blocks of storyboards and use the append or global replace functions of WordPerfect to make changes. Finally, and most importantly, since the automated storyboard is an integrated package, not a single storyboard is inadvertently omitted from the database.

Another feature of WordPerfect that was used to enhance the electronic storyboard was the capability of changing the keyboard definition. By reassigning the purpose of specific function keys (i.e., F10, Shift-F10, Control-F10) we designed a simple to use human interface that an inexperienced user can use. With the newly defined function keys, the new developer can activate, and utilize the electronic storyboard with minimum training.

Specific fields of the storyboard (Figure 1.), which are activated by a macro, are provided to accommodate the various team members assigned to the development team. Even though this storyboard is generic, the macro can easily be modified to accommodate any particulars (i.e., special branching instructions, or special menu items, etc.) of a specific project.

STORYBOARD #

The first field the developer will encounter deals with the numbering scheme of the storyboard. The developer inputs a numbering scheme which becomes the storyboard number. It is important that each developer be consistent in the numbering sequence, as all future work will be accessed by this number. As a local convention, this storyboard number can be traced directly back to the project flowchart(s).

SMPTE TIME:

Initially, this field is left blank since the SMPTE (Society of Motion Picture and Television Engineers) time code is not available until later in the development process. When the SMPTE time code is available (during the video shoot), the developer enters the required information. Once entered, the macro program automatically converts the SMPTE time code to the appropriate frame number. This is especially important during the programming stage, since coding of the videodisc can only be accomplished through the various frame numbers.

FRAME NUMBER:

This field displays the converted frame number once the SMPTE time code is entered in the previous field.

NARRATION:

This field of the storyboard allows the developer the opportunity to enter the narration or audio that will be used on the particular storyboard. As with all other fields, if there is no entry needed, it is left blank.

AUDIO TRACK 1:

This field is simply a Yes/No response as to whether audio track 1 is to be used.

AUDIO TRACK 2:

This field is simply a Yes/No response as to whether audio track 2 is to be used.

SCREEN TYPE:

The developer identifies the screen type (a standard convention developed within the organization that identifies a screen template to be used when framing a video shot) that will be employed with this particular storyboard.

AUTHOR:

Identifies the courseware developer responsible for the storyboard.

TASK NUMBER:

Storyboard reference to particular task item.

TECH ORDER REFERENCE:

This field is used to identify the subject technical reference of the storyboard.

SPLIT SCREEN:

A Yes/No prompt that identifies whether the video presented on the monitor will be in a split screen format.

If the response to this field is "Yes", the storyboard generates multiple object descriptions, otherwise it only presents a single subject description.

GRID/LOCATION:

A reference (either a grid location, specific location, or particular subject matter of the video shot) to distinguish the position of the subject matter that must be photographed.

NOMENCLATURE:

The specific name of the subject of the video shot.

DESCRIPTION:

A narrative description of the required shot.

TYPE SHOT:

A two letter identifier (CU-Close Up, MV-Medium View, FV-Full View, and MO-Motion Sequence) that specifies the type of video shot.

VIDEO TEXT:

In this field the developer enters any text that requires chyron generation (video text displayed directly from the videodisc).

COMPUTER TEXT:

Text that will be generated by the authoring system.

BRANCH TO STORYBOARD #:

Identifies the type of branch and the frame the student is to be branched to. The developer is prompted as to what type of branch, destination frame, and whether or not multiple branches will be used.

SPECIAL BRANCH INSTRUCTIONS:

The developer may identify in this field any special programming requirements needed for the frame or any type of special branching instructions.

REVISION DATE:

The macro automatically displays the revision date of the storyboard.

In addition, the courseware developer may display a graphic representation of the subject matter on the storyboard (within the figure box). This could be accomplished automatically by scanning

the subject matter, and using the graphic capabilities of WordPerfect.

STORYBOARD #: |
SMPTE TIME: |
FRAME NUMBER: |
NARRATION: |
AUDIO TRACK 1: |
AUDIO TRACK 2: |
SCREEN TYPE: |
AUTHOR: |
TASK NUMBER: |
TECH ORDER REFERENCE: |
SPLIT SCREEN: NO |
GRID/LOCATION: |
NOMENCLATURE: |
DESCRIPTION: |
TYPE SHOT: |
VIDEO TEXT: |
COMPUTER TEXT: |
UBR BRANCH TO STORYBOARD #: |
END BRANCH
SPECIAL BRANCH INSTRUCTIONS: |
REVISION DATE: |
:|

Figure 1. - Electronic Storyboard

PORT TO dBASE IV

After completing all inputs to the electronic storyboard and saving the data, the developer must convert the saved file from WordPerfect format to an ASCII (American Standard Code for Information Interchange) format. This conversion is required since the storyboard is initially saved in a WordPerfect format, and dBase IV does not recognize WordPerfect commands. The conversion is accomplished using the WordPerfect conversion program. The convert program allows conversion from selected programs to the WordPerfect format or from WordPerfect format to other text forms. Upon activating the conversion program, the developer is prompted to provide the input file name and the output file name that the conversion program will write to. The output file name must be different from the input file name. Once the output file is identified and the conversion is complete, the ASCII file must be ported to dBase IV.

DELIMIT PROGRAM

The delimiting program was written in Microsoft C 5.0[4]. The purpose of this program is to generate the delimited file for importation into dBase IV. Field names in the database system correspond to the topic names (storyboard fields) in the WordPerfect file. Therefore, the delimiting program can search the ASCII file for these topic names and once found, cross reference them with the dBase IV field names. When a match is found, the delimit program extracts the information from the ASCII file and exports it to a file compatible with the dBase IV field. Selecting this format for the importation has increased the portability of the storyboard data. This type of delimitation is commonly used to support importing or exporting into many other database management systems.

dBASE IV APPLICATIONS PROGRAM

After the storyboards have been created and saved in WordPerfect, converted into an ASCII format and then delimited with the delimit program, it is time to put the information into an easy to use format. "Easy to use" means that the developer will be able to access the storyboards and data desired by specifying a search criteria. For example, during a video shoot, the video producer/director can reduce video production time by reducing camera repositioning. To accomplish this, the *shot-list* must be able to group subject matter and camera angles. Therefore, by specifying a search criteria for all storyboards that use a specific subject matter and camera angle, the specified shot-list can be produced.

The package that was decided upon that would give us the data in the format desired was dBase IV. Besides having the ability to store and retrieve information in the format desired, dBase IV also had the added feature of a powerful applications generator. An applications generator is a tool used in automatic code generation of program files. We opted to use the dBase IV Applications Generator to shorten the program development time. By using the generator, other features were included in the applications program, such as networking. Even though a network is currently not used, the ability is there for future use. One of the disadvantages of using an applications generator is that the code generated suffers from what is known as "code bloat". In other words, the resulting code is not necessarily streamlined or the most efficient, however for our purposes, the advantages of the generator outweighed the disadvantages.

Upon entering the dBase IV applications program, each developer is pathed to a menu screen (Figure 2.) from where they are able to manipulate data. The

following is a synopsis of the functions available from the applications menu:

APPEND WordPerfect Data
Add Info Manually
Change Information
Browse Information
Sort Information
Generate Report
Exit to Command Center
Exit to DOS
<F1> for Help

Figure 2.

APPEND WORDPERFECT DATA:

The append function of dBase IV allows users to add records to the end of an existing database file. The applications program takes the delimited ASCII file that was created from the delimit program and appends the information into a database file. This database file is created automatically, and is appended each time new information is added into the delimited ASCII file.

ADD INFO MANUALLY:

This option allows the developer to add information manually to the database file. Caution must be taken using this function since the automatic information transfer between dBase IV and WordPerfect is a one-way track. Information can only be processed automatically from WordPerfect into dBase IV, and not vice-versa. If the developer needs to add information to the storyboard, it is recommended that this information be added into WordPerfect, and then "appended" into dBase IV.

CHANGE INFORMATION:

This option allows the developer to alter existing information contained within the database. Again, as with "**Add Info Manually**", care should be taken using this function due to the information transfer between programs. If the informations is changed manually within the database, it must be changed manually within Word Perfect.

SORT INFORMATION:

This option sorts the information contained in the database by the storyboard number. If there are duplicate storyboard numbers, the oldest storyboard record is deleted, and then all remaining records are sorted in an ascending manner. This option should be used following any alteration or manual addition of the information contained within the database.

GENERATE REPORT:

This option will display a dBase IV menu containing report forms that may be generated by the system. Depending on the need, shot lists, graphic requirements, programming instructions, lesson text, etc., may be produced. Each project team may develop additional reports as the need arises.

EXIT TO COMMAND CENTER:

This option paths the developer to the dBase IV "dot" prompt. (consists of a single dot indicating dBase IV is ready to receive a command, similar to the DOS> prompt)

EXIT TO DOS:

This option exits the dBase IV application program and returns the developer to the DOS prompt.

CONCLUSION

In the Computer-Based Training (CBT) development process, creating flowcharts and storyboards is both necessary and time consuming. On average, 40-50 percent of the total program development time is attributable to these two activities. With the additional requirement of incorporating video in an IVD training project, the development process becomes even more complex and time consuming. In the past, courseware developers have of necessity manually generated stroyboards from flowcharts and then manually inputted video requirements into the database. This procedure tended to be both time consuming and mistake prone. To facilitate this complex data collection process, an automatic integrated software package was created. This automated package has produced a significant decrease in development time, while reducing the human error factor when manipulating a massive amount of data. It must be noted, however, that this package, although effective, is not finalized. Further customizing will evolve as needs of future projects arise.

ENDNOTES

1. WordPerfect is a registered trademark of Word Perfect Corporation.
2. MIL-HDBK-ICWA, *Interactive Courseware Glossary of Terms for Department of Defense Interactive Courseware (ICW) Acquisition Manager's Guide,* Joint Service Action Group: 11 July 1989.
3. dBase IV is a trademark of Ashton-Tate Corporation.
4. Microsoft C 5.0 is a registered trademark of Microsoft Corporation.

A MODEL FOR COMPETENCY-BASED TRAINING AND DEVELOPMENT

Donna Gregory and Ed Rao

Abstract

Today's employers have a challenge to meet the needs of a rapidly changing work place and work force. The U.S. General Services Administration (GSA) has formalized its training strategy for professional development of its employees, through establishment of an Occupational Certification Program. This is a competency-based development program which was implemented in 1988 to meet these demands.

This paper describes the multipurpose job analysis procedure used to develop a competency-based training model and related performance standards to reinforce training. This provides a system for relating the requirements of the job to the abilities of the employees. It focuses on training requirements, training sources, and the proficiency of performance.

DONNA GREGORY is a Personnel Psychologist with the Office of Quality Management and Training in the U.S. General Services Administration. She is responsible for the agency-wide Occupational Certification Program which currently covers 33 of GSA's major professions, and the management and executive development programs. She implemented a multipurpose job analysis method in GSA which has led to the establishment of integrated personnel documents for purposes of selection, performance evaluation, and training and career development.

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A MODEL FOR COMPETENCY-BASED TRAINING AND DEVELOPMENT

Introduction

Forecasts for the future make it clear that new approaches to employee recruitment, development, and retention are necessary.1 Employers face many challenges dues to the rapid technological and demographic changes. With these changes, the idea of hiring fully trained workers is disappearing. Industry and public service organizations must develop their work force to meet their special needs.

The U.S. General Services Administration (GSA), a central management agency that sets policy in such areas as government procurement, real property management and telecommunications services, began to look at transitional training for the 1990s several years ago. It is necessary to identify more efficient ways to train the work force and to remain competitive. To improve program performance and employee development, and to professionalize the work force GSA established the Occupational Certification Program. A competency-based approach was used to establish a certification training model which focuses on training for new skills, upgrading skills and career development.2 The training model is reinforced by performance standards that are competency-based with measurable, observable, and attainable outcomes.

Background

Several public and private sector studies by the Hudson Institute, the Rand Corporation, and others have identified poor training as a major cause of high turnover and poor performance.3 Training does not stop at the school door. Sixty percent of an individual's training occurs in the work place. The focus must be on education, training, and retraining. The Certification Program establishes minimum professional standards and the training and development requirements for the profession.4 This training strategy is in place for 33 occupations, including support staff, professional and administrative personnel, as well as for supervisors, managers, and executives. The Certification Program uses a competency-based training model. (Figure 1 represents the competency model in a flowchart format.)

Methodology

A multipurpose job analysis method was used to provide the basis for content-oriented validation of the occupational training plans and the related performance standards.5 This data also was used for developing selection procedures. The job analysis approach allows the development of an integrated system of personnel documents needed to meet overall personnel management responsibilities. This paper will focus on the training model and performance standards.

GSA's Career Development and Training Division coordinated the overall development of the Certification Program. However, it is essential that program development and implementation become a joint effort between management and the human resource organization. Management must take an active role in diagnosing training needs, overseeing program development and administration, and in some cases even delivering the training.6

A job analysis was conducted for each occupation. Task groups consisting of job experts, typically senior level employees or program managers, were assembled by occupation. The occupational job experts generated a list of work behaviors or job duties which were further broken down into the specific job tasks necessary to perform each duty. The job experts evaluated the tasks on several dimensions, including importance to the job and percentage of time spent performing the tasks. Competencies needed for the performance of the tasks were identified and rated on overall importance to the job, time spent performing, necessity at entry, and extent the competency differed among levels of job performance.

The job analysis identified and clearly defined the major duties, job tasks, and learning objectives. The competencies or knowledge, skills and abilities needed to perform the job tasks were defined. Training curriculum was then linked to each of the competencies. The job experts determined the most appropriate types of training activities for the development or enhancement of each of the competencies. A wide variety of formal and informal training activities were identified, including formal classroom training, rotational

assignments, seminars, workshops, self-learning instruction, and on-the-job training assignments. Diversity of experience and exposure to different kinds of assignments was emphasized.

Multipurpose Job Analysis

An integrated multipurpose job analysis approach provides the basis for the content validation strategy used to support personnel processes such as selection, performance appraisal, and training.7 This method for collecting task-oriented information complies with regulatory guidance (Uniform Guidelines on Employee Selection Procedures) and provides the direct linkage and job-related documentation to support the development of personnel documents. (Government Employee Relations Report [77-CV-343] 829:74 [para 183]). Further, the results produced using multipurpose job analysis systems have a demonstrated history of acceptance to the courts. (U.S. v. New York, W.G. Connelie, et al.,). The method meets both the psychometric and legal issues affecting job analysis practices. (Bemis, Belenky, and Soder (1983).

The ability to tie the job tasks and knowledge, skills, and abilities into an integrated personnel approach which produces the selection criteria, training criteria, and performance evaluation criteria increases the power and utilization of the method and the products.8

The Certification Model

A training plan identifies the job functions, competencies, and training and development needed for an individual to progress through the profession, from the entry level to the journey level. The plan provides a formal and structured career development path with specific training and development activities matched to each competency and designed for employees to gain expertise in their professions.

Employees can be formally certified in their professions once they have met the full set of certification criteria and have demonstrated proficiency of the required competencies. The employee's training and progress is monitored by the supervisor and an Occupational Review Panel consisting of job experts in the agency. The Panel recommends certification of eligible employees to top management officials.

The major objectives of the program are:

o To orient new employee to their jobs.

o To improve the performance capabilities of employees.

o To prepare employees for advancement and career development.

o To improve employee morale and job satisfaction.

The job analysis information provided the foundation for the development of the formal certification training plan. (See Figure 2 illustrating the linkage of managerial competencies to training course curriculum.) This process relates job functions or tasks to conditions of training in order to select optimal methods and of training and measures of job performance.9 Training tasks are established to reach training goals.

An application-oriented approach to training with measurable and observable outcomes is important to a successful development program. Performance objectives cannot be ignored when setting up a training program. Competency-based performance standards were developed using the job analysis information. This created a model performance plan with observable and directly relevant job behaviors. This plan serves as a broad description of the type of performance that is expected of a typical employee in the occupation. Performance standards were developed that identify specific examples of behavior for expected performance and for performance that significantly exceeds normal expectations. The linkage between the training plan and the performance plan is critical to employee development. It provides a system for relating the requirements of the job to the abilities of the employees. It creates a means to provide relevant feedback to employees on their performance and development.10

The Certification Program focuses on the proficiency of performance and application in a work setting. Competencies focus on performance as opposed to knowledge. The training model is reinforced by performance measures which enhances the focus of training.11 (See Figure 3 which illustrates the multipurpose job analysis

approach and the linkage of performance requirements to training and employee evaluation.)

Highlights of the Plan

Several unique features of this plan are:

1. The Certification plan is based on a competency training model, wherein a thorough job analysis identifies the qualifications or competencies of a particular position.

2. Competency focuses on performance as opposed to knowledge. As in a work setting the application of the knowledge is more important than simple recall.

3. Training tasks established to reach training goals, integrate work assignments with formal training and special seminars in relevant topics of job responsibilities.

4. The individual development plan has a specific course of action, with training resources identified for ease of implementation.

5. The individual development plan is in a checklist format that makes it easy for the employee and supervisor to administer and monitor the progress of the participant in the Certification Plan.

6. Competency-based performance standards with measurable, observable and attainable outcomes are built into model performance plans. The performance measures are used to reinforce training and to provide a method for relating the requirements of the job to the abilities of the employees.

Conclusions

Today's training philosophy needs to reflect our current situation. It is necessary to provide incentives, challenges, and encouragement to all employees to continue to learn and grow, both professionally and personally. The GSA Certification Program is designed not only to attract motivated and qualified individuals, but to challenge them with opportunities to expand their knowledge and stay abreast of new trends in their fields. The program ensures that our employees have the skills and necessary training to perform their current jobs. It provides the guidance for cross-training and retraining employees to meet work force needs for the future.

The program promotes the development of employees which it is hoped will ultimately enhance the quality of performance and productivity of the overall work force. Through certification, employees are recognized for professional competence in their professions. Employees completing the program are recognized and receive a certificate of accomplishment. Career development is an effective recruitment incentive for individuals entering the government. It ensures that they will receive training to attain the knowledge and skills needed for success in their fields. The program serves to retain employees by providing job enrichment and opportunities for cross training or new skill development. The agency receives the benefits of an efficient, effective, and productive work force.

This Certification Program has been immensely beneficial to the individual candidates through their development; to management by creating a professional staff; to the agency by enhancing the efficiency and productivity of the work force; and to the customer by enhancing the quality and timeliness of GSA service delivery. An evaluation of the program is currently underway.

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5 Veres, III, John G., Lahey, Mary Anne, and Buckly, Ricki. "A Practical Rationale for Using Multi-method Job Analyses," Public Personnel Management, Vol. 16, No.2 (Summer 1987), 1,53-156.

6 GSA Task Group on Management Development and Performance, " The GSA Managerial Excellence Program," 1990.

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11 Sahl, Robert J. "Assessment - Design Effective Performance Appraisals," Personnel Journal, October, 1990, 53-60.

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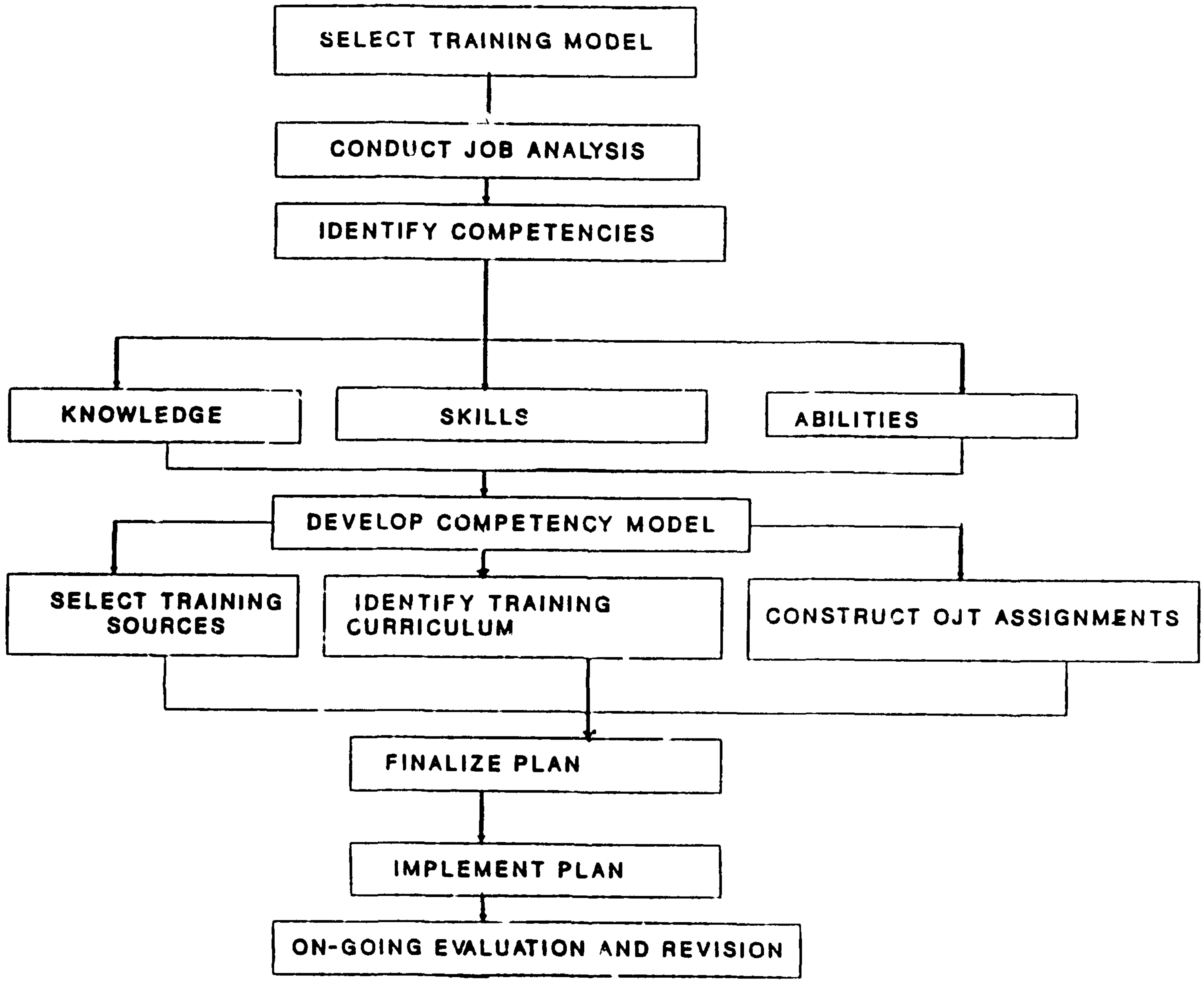
FIGURE 1

COMPETENCY MODEL FLOWCHART



Certification Training Plan

No.	Topic (Course) Sample Representation	Competencies: Personal Effectiveness					Resource Management		Team Effectiveness					Program Management		Policy Management				
		Oral Communication	Written Communication	Interpersonal Sensitivity	Technology Management and Application	Technical Competence	Administration of Money and Material Resources	Utilization of Human Resources	Planning and Guidance	Leadership	Results Focus	Flexibility	Action Orientation	Budgeting	Review of Implementation and Results	Represents, Coordinates and Communicates	Integrates External and Internal Issues	Broad Perspective	Strategic View	Organizational [illegible]
1	Effective Executive Speaking	X																		
2	Effective Writing for Executives		X																	
3	Effective Speaking and Human Relations	X		X												X				
4	Computer Literacy for Managers				X															
5	Specialized Expertise in Specific Areas (Engineering, Accounting, and Contracting)					X														
6	The Federal Budget Process						X							X						
7	Performance Management							X		X										
8	Planning for Organizational Effectiveness								X	X	X									
9	Leadership Development for Today's Manager									X										
10	Managing Self and Others for Peak Performance			X						X	X		X							
11	Managing Change Successfully											X								X
12	Workshop in Organizational Action										X		X							
13	Program Evaluation Methods														X					
14	Budgeting and Accounting for Non-Financial Managers						X							X						
15	Executive Image Program	X														X				
16	Executive Development Seminar								X	X							X			
17	Leadership Conference									X								X	X	
18	Managing and Thinking Strategically														X				X	
19	Conflict Management in Organization									X	X									

Figure 2

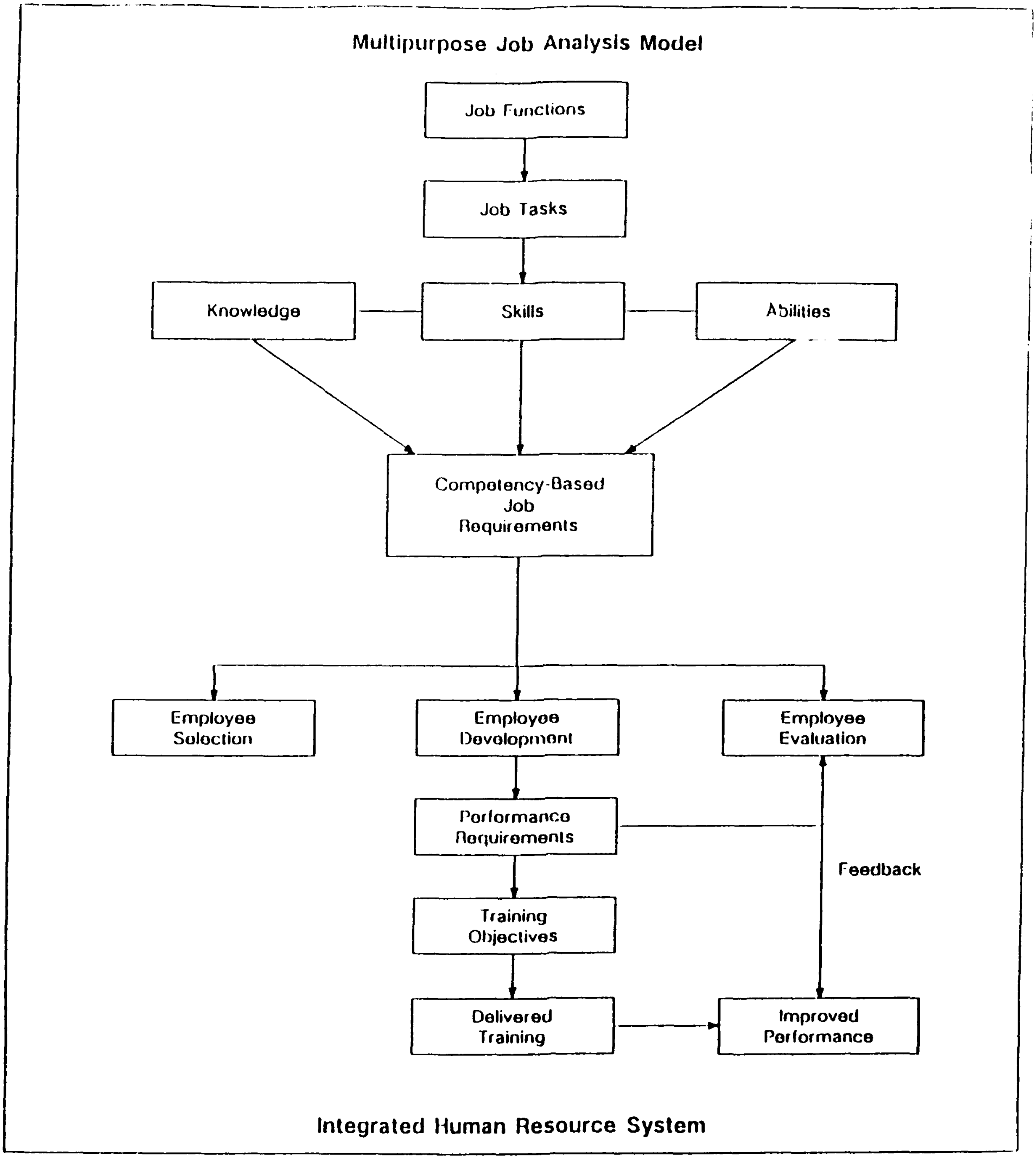

Multipurpose Job Analysis Model
Job Functions
Job Tasks
Knowledge
Skills
Abilities
Competency-Based Job Requirements
Employee Selection
Employee Development
Employee Evaluation
Performance Requirements
Feedback
Training Objectives
Delivered Training
Improved Performance
Integrated Human Resource System

Figure 3

DEVELOPMENT OF A CONCEPTUAL METHODOLOGY FOR A COMPUTER-BASED AIDING/TRAINING DECISION SUPPORT SYSTEM

John P. Zenyuh, William B. Rouse, Phillip C. Duncan
Paul R. Frey, and Theodore A. Lamb

The ever increasing complexity of operational Air Force systems coupled with decreasing force levels, declining entry-level skills and the need to reduce military expenditures is placing an unprecedented demand on Manpower, Personnel and Training (MPT) agencies to improve operational effectiveness with fewer available resources. One component of the overall solution is the selection of effective and efficient training/aiding programs. However, selecting among the wide variety of training and aiding alternatives (and the possible combinations) is difficult when a myriad of interdependent factors such as system design impact (e.g., to automate or not automate), aiding/training development costs, and implementation requirements must be simultaneously resolved. In response to this need, the Air Force Human Resources Laboratory at Brooks AFB has sponsored the Job Aiding/Training Allocation Technologies (JATAT) program for the purpose of developing a conceptual aiding/training decision support methodology for personnel in complex systems.

The fifteen-step methodology developed during this effort is a human-system performance-based approach to identifying applicable aiding/training alternatives for complex system tasks and for evaluating the candidate aiding/training solution sets. The fifteen steps can be summarized by the following six activities: Identify Tasks; Assess Human Limitations, Abilities, and Preferences; Determine Alternatives; Formulate Tradeoffs; Analyze Tradeoffs; and Integrate Tradeoffs. This paper describes the JATAT methodology and the subsequent data requirement issues.

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DEVELOPMENT OF A CONCEPTUAL METHODOLOGY FOR A COMPUTER-BASED AIDING/TRAINING DECISION SUPPORT SYSTEM

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Theodore A. Lamb

INTRODUCTION

The ever increasing complexity of operational Air Force systems continues to place greater demands on the personnel operating and maintaining them (AFHRL Report, 1986). The increased sophistication of these systems coupled with decreased force levels, declining entry-level skills, and the need to limit military training spending are forcing Manpower, Personnel, and Training (MPT) agencies to seek more efficient methods of maintaining and improving operational readiness (Booher, 1978; Duncan, 1985).

In this environment of "doing more with less" the issues of training and job aiding are paramount. Technical training serves as the source of knowledge and skills essential to task performance. In other words, training "creates the potential to perform" (Rouse and Johnson, 1989). Job Aiding, collectively, refers to those devices with the capacity to store and retrieve the "How", "What", and "When" information pertinent to the performance of a particular task. Job aiding, therefore, directly augments performance (Rouse and Johnson, 1989).

Selecting from among the wide variety of training and aiding alternatives (and their possible combinations) is difficult when a myriad of interdependent factors such as performance-related effectiveness, development/implementation costs and system design impact must be simultaneously resolved. For example, as an information storage device, a job aid facilitates performance by reducing task-related memory requirements. This, in turn, reduces the training requirements for that job and generates the potential for reducing immediate resource expenditures. Training, on the other hand, imparts more general knowledge applicable to a variety of related tasks. In this case, the increased capital costs of training a small, multi-disciplinary work force may, in the long-term, be more cost effective than the life-cycle costs of supporting a larger, more specialized team.

The formulation and evaluation of these aiding/training tradeoffs is a necessary component of the decisions made by MPT analysts, system designers, and personnel supervisors throughout the Air Force. To the extent that these tradeoffs have been addressed in the past, the analyses have required many person-years of effort. Often, the result has been a time-consuming and expensive effort that provided insights which were too late to be implemented in any substantial way (Rouse and Johnson, 1989). Whether for evaluating current AFS job performance, selecting among new system design alternatives, or ensuring that flight-line personnel are task qualified, a methodology for efficiently producing consistent, timely, and supportable aiding/training decisions is a must.

In response to this need, the Air Force Human Resources Laboratory at Brooks AFB has sponsored the Job Aiding/Training Allocation Technologies (JATAT) program. The

purpose of JATAT was to develop a conceptual decision aiding methodology to assist in identifying applicable training/aiding alternatives and evaluating combinations. The expected benefits of such a methodology include faster, more accurate, and auditable performance-based aiding/training recommendations.

OVERALL DESCRIPTION

In a prior report, Rouse and Johnson (1989) suggested three computational approaches for supporting trade-off decisions between training and job aiding. The first approach involves compiling general guidelines for training/aiding decisions based on cumulative experience and experiments. This results in a "rule-based" approach in which tradeoffs are embodied in rules based on mappings from task performance requirements to training/aiding decisions.

The second approach involves predicting human-machine system performance based on attributes of specified training and aiding alternatives. This approach enables the analyst to specify the appropriate performance measures and acceptable levels of performance in different situations and with different priorities. This requires computational models that predict the measures of interest based on the available attributes of the training or aiding alternatives. These models are a more "visible" form of the first approach in that the first approach may "hide" the measures and requisite levels of performance in the rules or guidelines.

If the rules, guidelines, or computational models do not exist or are not adequate, then the analyst can use simulation techniques to estimate performance measures of the human-machine system using different training or aiding alternatives. This third approach is actually a special case of the second. In this case, the analyst must develop or tailor a simulation model to predict the chosen measures of performance.

The methodology described in this paper encompasses these three approaches, placing them in the larger context of a training/aiding trade-off analysis (see Figure 1). Steps 1 and 2 of the method reflect a typical systems engineering approach to the analysis. Step 3 indicates a human-centered approach to identifying the requirements that will be addressed in the analysis. Steps 4 through 15 of the method (in which the analyst determines the alternatives and formulates, analyzes, and integrates the tradeoffs) describe an ordered approach to the complex problem of analyzing multiple, interdependent tradeoffs between aiding and training the human.

Although presented as an ordered list in Figure 1, these steps are not necessarily sequential. Some of the steps may be repeated several times as the analyst/designer works through the tradeoffs under various conditions and with various combinations. The following sections discuss these steps in detail.

INDIVIDUAL STEP DESCRIPTION

IDENTIFY TASKS

1. Understand the Job. In the context of analyzing job aiding/training tradeoffs, the analyst must understand three different aspects of the job: the tasks involved in the job, the equipment used in the job, and the personnel expected to do the job. This knowledge is necessary to determine the job requirements and system constraints that must be satisfied. Obviously, complete knowledge of these variables for all tasks is unrealistic. In fact, the required level of understanding is

directly dependent upon the problem at hand. For example, a decision to train or aid personnel to perform a job requires far less detailed information than a decision among combinations of a specific task.

2. Decompose via Task Taxonomy. The second step is to further decompose the tasks into more primitive tasks, referred to as subtasks or activities. This decomposition defines the level of granularity for subsequent steps (the assessment of the human's limitations, abilities, and preferences). A task taxonomy is useful in this step, particularly if the human's limitations, abilities, and preferences are readily determined for the task elements in the taxonomy.

ASSESS LIMITATIONS, ABILITIES, AND PREFERENCES

3. Assess Human Limitations, Abilities, and Preferences. In this step, the analyst determines those characteristics of the human in the system that either require (through human limitations) or influence (through human abilities and preferences) training/aiding decisions. It is this focus on the human capabilities, limitations, and preferences in the system that makes this a human-centered approach.

This assessment draws its primary input from the task decomposition in the previous step, which provides an "index" for human limitations, capabilities, and preferences. In subsequent steps, these assessments will be used to identify training and aiding alternatives. A task decomposition that is too coarse leads to identifying general human limitations that are not sensitive to the aiding/training alternatives available. A task decomposition that is too fine grained leads to identifying human limitations that require premature detailed design of aiding/training alternatives to evaluate.

DETERMINE ALTERNATIVES

4. Map Limitations, Abilities, and Preferences to a Taxonomy of Training Alternatives.

5. Map Limitations, Abilities, and Preferences to a Taxonomy of Aiding Alternatives. Through Steps 4 and 5, the analyst uses the limitations and abilities identified in Step 3 to guide the identification and selection of alternative training and aiding techniques. This is done by identifying the knowledge and skill requirements of a task and mapping the required changes in knowledge and skills to candidate aiding/training methods through guidelines. The mapping is guided by available expert heuristics or empirically developed guidelines.

From a pragmatic perspective, other factors may also go into this process, such as resource availability and existing training or aiding techniques for this or similar jobs. Depending on the maturity of the analysis and the expertise of the analyst, these considerations may either prematurely constrain the solution space (early in the analysis) or provide timely guidance leading to practical solutions (later in the analysis).

FORMULATE TRADEOFFS

6. Make Obvious Choices. In this step, the analyst selects among training/aiding alternatives that are straight-forward and require no additional analysis. This step allows for the situation in which part of the problem is easily addressed by conventional solutions. For example, printed procedural job aids may be an obvious solution for a task which is similar to one already using that type of aid extensively.

Clearly, these choices depend upon the expertise of the analyst as well as the data and tools available to the analyst. A relatively novice analyst may be unable to independently make obvious choices, but may be able to rely upon tools such as heuristic guidelines, decision flow charts (Booher, 1978), or expert judgement models (Irvin, Blunt, & Lamb, 1988) for making broad categorical decisions (e.g., train, aid, both, or either). A more experienced analyst may also want to use these tools to verify their choices.

Making the obvious training/aiding choices now, however, does not remove them from further consideration. Their interdependencies must still be considered in later steps.

<u>7. Coalesce Interdependent Tradeoffs.</u> To this point in the analysis, the number of viable alternatives has been relatively unlimited. However, once obvious choices have been made, subsequent analyses can be quite extensive. Therefore, it is usually necessary to narrow down the number of candidate solutions by grouping training and aiding alternatives according to their interdependent relationships and characteristics.

For example, a particular task element may suffer from a limitation that may be addressed by one of three alternatives: training alone, aiding alone, or some combination of training and aiding. It is likely that these task elements will be functionally or temporally interrelated. Similarly the training and aiding alternatives will probably have interdependent interdependencies and coalesce the training/aiding alternatives into a smaller set for subsequent analysis.

<u>ANALYZE TRADEOFFS</u>

<u>8. Choose Measures of Performance.</u> Accurately evaluating the resultant training/aiding alternatives requires selecting the appropriate performance measures. These measures are clearly domain dependent. Cost, for example, is a basic measure of performance common to all domains; although its importance will vary accordingly. Other examples include time to perform, probability or number of errors, mean time between failures, etc.

The choice of performance measures is also influenced by the available modeling tools and modeling expertise of the analyst. While a more experienced analyst may choose to tailor the available modeling tools or develop new models to produce a variety of performance measures, a novice will probably have to choose among "pre-determined" models that are readily available.

<u>9. Choose Input/Output Representations.</u> To compare training/aiding alternatives, an input/output (I/O) representation (i.e., a model) must be chosen that can produce the selected measures of performance. The I/O representation must reflect realistic inputs from available data and the desired outputs including the performance measures.

Once again, the experience level of the analyst strongly influences the extent of this step. While a more experienced analyst may be able to adapt existing models or develop new ones, the choice of I/O representation for novice will more likely follow directly from the choice of performance measure.

<u>10. Identify Requisite Structures and Parameters for Representations.</u> Employing the chosen I/O representation frequently requires modeling the human as an integral component of the system. In doing so, it may be necessary to determine the structures and

parameters that represent how the human performs the task. If the analysis includes only aiding alternatives, these requirements may be essentially constant throughout the analysis. In analyses that include training alternatives, these requirements will vary to simulate the impact of different training alternatives.

11. If Necessary, Represent the Learning Process. In some analyses, the performance measures may be sensitive to the human process of acquiring knowledge and skills. In these cases, the learning process must be reflected in the model. This representation may be as simple as retrieving data from a database or as complex as employing learning curves or learning process models.

12. Apply Methods of Analysis to Representations. This step invokes the targeted analysis; input data is supplied, the model is exercised, and performance data is collected for each of the training/aiding alternatives of interest.

13. Interpret Results. Next, data collected during the previous step is analyzed and interpreted in the context of selected analyses. This step may be repeated several times in conjunction with steps 10 through 12 as the analyst investigates the effects of various assumptions or the sensitivity of the performance measures to variations of the parameters within the model.

INTEGRATE TRADEOFFS

14. Compile Assumptions and Consequences of Tradeoffs. In an extensive analysis with a number of different tasks and training/aiding alternatives, organizing the assumptions and consequences of the trade-off analyses is a large bookkeeping task. The purpose of this step is to compile all the common aiding/training alternative characteristics and decisions in order to implement the predetermined aggregation guidelines in the following step.

15. Form Sets of Tradeoffs with Consistent Assumptions and Consequences. In the final step of the methodology, the training/aiding alternatives are integrated into sets satisfying the requirements developed from the human limitations, abilities, and preferences identified in Step 3. In addition to satisfying these requirements, each set incorporates the common assumptions and consequences (i.e., learning and retention abilities of humans or productivity improvements with job aiding) identified in the previous step.

While most analysts will probably not have the final decision-making authority necessary to implement the recommendations produced in a JATAT analysis, this methodology generates a logical justification supporting these recommendations. The purpose of this step, therefore, is to compile a clear, coherent summary of that justification.

SUPPORTING DATA TYPES

Similar to other decision aiding paradigms, the JATAT methodology is extremely data dependent. The type/format of data required by each component of the decision process varies as a function of the characteristics of that intermediate decision construct. For JATAT, these data requirements can be classified as archival data, user-provided contextual information, and expert rules/heuristics.

Archival data is the factual personnel, task, and equipment information typically collected through occupational surveys or compiled from system operation and maintenance documents. This includes

such data as task/sub-task listings, performance times/probabilities/and requirements, task and equipment complexity, aptitude/experience, and training indicators. In the JATAT aiding/training decision support paradigm, archival data serve as both the target data to be processed by the JATAT models, and as the user's source of domain knowledge. Currently, this information resides in a miscellany of data sources which include the Occupational Research Data Bank (ORDB), AF Regulations, career development training manuals, Air Training Command Plans of Instruction (POI's), and equipment technical manuals.

Contextual information is the abstract, highly situation specific data which represents the background scenario of the archival data. This information is primarily characterized by its relational nature. It encompasses those factors which preceded (and subsequently, effected) the aiding/training analysis, and the environmental ramifications (i.e., political, temporal, and resource-related) of the candidate aiding/training solutions. Due to the context specific/temporal nature of this data the JATAT aiding /training decision analyst is the sole source of this information.

The aiding/training expert rules/heuristics contain the knowledge which guides the analysis process, generates aiding/training recommendations, and simulates target system performance. This data is primarily in the form of taxonomies and expert rules resident in the system knowledge bases. Included in this category are potential training/aiding methods, training philosophies, operational/system knowledge requirements, modeling packages, input/output parameters, etc. This knowledge must be established during the system design and development phases and is obtained through knowledge acquisition sessions with relevant domain experts.

LESSONS LEARNED

In order to verify the robustness of the newly developed JATAT methodology, we preformed two aiding/training trade-off analyses of pre-selected Air Force Specialty tasks based on available operational data. The lessons learned from this experience were two-fold. First, the JATAT methodology developed during this effort successfully serves as a generic decision framework for supporting accurate, auditable aiding/training trade-off analyses. And second, current Air Force occupational survey procedures must be reevaluated in order to support integrated decision support models, such as JATAT. This reevaluation process must, at a minimum, address the issues of data availability and standard task definitions.

DATA AVAILABILITY

Data availability, in this case, is defined in terms of the data's format (i.e., how closely the existing data format conforms to that required by the decision models defines the degree of pre-processing necessary) and the medium within which the data resides (i.e., hardbound copies vs. a computer-based data bank). Each level of extrapolation, interpolation and media transformation required to apply the data to the methodological framework, in essence, decreases the inherent utility of the data. Unfortunately, current data sources vary widely along both of these dimensions. Therefore, commitment and effort will be required to structure available data sources to more directly support the integrated environment of the many new decision aiding models.

STANDARD TASK DEFINITIONS

The importance of formulating universally accepted, standardized task definitions (i.e., terminology and level of resolution) represents a single, cogent conclusion drawn from three independent issues. First, the accuracy of a decision aiding application is directly dependent upon the mapping of an unfamiliar task to a well-understood taxonomy. Complicating this mapping by representing tasks at various levels of abstraction decreases the power and success of the aiding/training recommendations. The second issue supporting the pursuit of a standardized task definition effort is that current task listings lack consistency in their granularity of task specification. For example, the Air Force Occupational Research DataBank specifies both form completion and propulsion system trouble-shooting at the task level. No explicit standard is established regarding time required, number and/or type of activities involved, focus of aiding/training solutions, etc. This inconsistency among critical task dimensions also complicates the process of transitioning information among different decision models. Recent Air Force emphasis on MPT model integration, the third issue, is directed toward developing consistency and relatedness among the numerous decision models. Definition standardization within, and across, models and databases is essential to facilitate such a concept.

SUMMARY

This paper describes a generic methodological framework for making job-aiding and training trade-off decisions about a wide variety of operational Air Force tasks. These tasks may be anything from trouble-shooting complex aircraft avionics to patrolling airbase perimeters. currently, these analyses and results, inherent to the JATAT decision process, are purposely *grounded in human-system performance* attributes and predictions. Subsequent efforts will be needed to address the issues of cost and operational constraints.

The potential impact of a computer-based application of the JATAT decision aiding methodology on Air Force Manpower, Personnel, and Training (MPT) issues is the ability to provide logical arguments for the construction of job-aids and empirical justification for the manner in which we decide to train specified tasks. While the successes of these efforts make no implications regarding the maturity and readiness of the technology necessary for implementing the JATAT methodology, they do indicate that the solution is tenable. It will be further research into the areas of the input factor relationships within the aiding/training domain, continued trade-off decision methodology formulation, supporting database development, predictive model generation, and the design of decision support system functionality that will help bring the JATAT concept to reality.

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IDENTIFY TASKS

1. UNDERSTAND THE JOB
2. DECOMPOSE VIA TASK TAXONOMY

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ASSESS HUMAN LIMITATIONS, ABILITIES AND PREFERENCES

3. ASSESS HUMAN LIMITATIONS, ABILITIES AND PREFERENCES

↓

DETERMINE ALTERNATIVES

4. MAP LIMITATIONS, ABILITIES, AND PREFERENCES TO A TAXONOMY OF TRAINING ALTERNATIVES
5. MAP LIMITATIONS, ABILITIES, AND PREFERENCES TO A TAXONOMY OF AIDING ALTERNATIVES

↓

FORMULATE TRADE-OFFS

6. MAKE OBVIOUS CHOICES
7. COALESCE INTERDEPENDENT TRADE-OFFS

↓

ANALYZE TRADE-OFFS

8. CHOOSE MEASURES OF PERFORMANCE
9. CHOSE INPUT/OUTPUT REPRESENTATIONS
10. IDENTIFY REQUISITE STRUCTURE AND PARAMETERS FOR REPRESENTATIONS
11. IF NECESSARY, REPRESENT THE LEARNING PROCESS
12. APPLY METHODS OF ANALYSIS TO REPRESENTATIONS
13. INTERPRET RESULTS

↓

INTEGRATE TRADE-OFFS

14. COMPILE ASSUMPTIONS AND CONSEQUENCES OF TRADE-OFFS
15. FORM SETS OF TRADE-OFFS WITH CONSISTENT ASSUMPTIONS AND CONSEQUENCES

EXPANDING THE USEFULNESS OF ANALYSIS AND DESIGN INFORMATION

Jeff Clark

ABSTRACT

ISD methodology used on large, complex training programs generates enormous amounts of information. All the information must be organized and put in to formats that are usable by managers, subject matter experts and instructional designers. The purpose of creating this information is to facilitate decision making, and to find and document the most efficient and effective training structure attainable given the assets and constraints. Now, using newer computer technology and database software, analysis and design information can also be used to create a wide range of training products. These products include job survey forms, self evaluation checklists, job aids, academic tests, and job performance measures. This dramatically increases the value of analysis and design information.

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EXPANDING THE USEFULNESS OF ANALYSIS AND DESIGN INFORMATION

Introduction

Traditionally, analysis and design data have been used to describe jobs, identify the skills, abilities, and knowledge required for competent performance of the job, and to define the structure of training programs. Rigorous use of these processes has generally resulted in more effective and efficient training.

Now, we are able to go beyond those classical uses of analysis and design data in several important ways. First, we can make the training more consistent with actual job performance by using software to track the link between the job/task analysis, objectives, and the finished training program. This link lets the developer see what job/task analysis information has not been used to develop objectives, and conversely what objectives have been created that do not have a link to the job/task analysis. This enables the designer to control the content of the training program and provides a rational basis for deciding what should and should not end up in the training program.

In addition, the designer can track where in the training program specific job/task analysis components are taught. If equipment is changed, the designer can quickly assess the impact on existing training.

Another important new capability is the creation of useful training products directly from an analysis and design database. Typically, analysis and design data have been used and then forgotten. But computer technology with larger storage devices and faster processing speeds, is giving us new opportunities to make use of this valuable information. Some of the products that can be generated directly from analysis and design data include job survey forms, task analysis worksheets, job aids, self evaluation checklists, academic tests, and job performance measures.

These documents are created independently of one another and yet they all share common information. For example a task statement can show up in a job analysis, an objective, a job aid, and on a job performance measure. If the task changes, then these documents are probably effected. Gradually, these documents get out of phase with one another and inconsistencies creep into the information with the resulting inconsistencies in the training.
There are several ways of dealing with these inconsistencies. One is to ignore them until they become an unavoidable problem. Usually this strategy is used by those that view analysis and design information as a means to an end and have thrown the analysis and design data away or put it in a file somewhere. When the training gets out of phase with the job it purports to train, analysis and design activities are started again.

Another solution has been to institute a controlled documents policy. Procedures are put into place that specify how and when changes are made to important training documents. However, these documents are created separately using a combination of database and word processing software. Updates to one document doesn't change the

content of related documents. So document maintenance becomes a very labor intensive process and still doesn't completely solve the problem.

A third and newer possibility is to have all the information required to produce these documents in a set of integrated software programs. (Integration in this context means that job/task analysis, objectives, program design, and associated information all reside in one database.) It is now possible to do this, and several important things happen as a result. The analysis and design database can be used to facilitate program revisions and maintenance. It can also be used to generate training documents. When updates are made they are reflected in many different parts of the program at the same time and the training products are kept current.

Specialized Software

To maintain the documents and get them from one database, two critical things have to occur. There must be a software package that can handle the complex relationships that exist between the different types of training information and there must be a plan for the structure and organization of the database. At a minimum the software should have these capabilities:

1. Represent the job and task analysis in a flexible hierarchical format that defines relationships between the job, its duty areas, tasks, performance steps, skills, and knowledge statements,
2. Maintain the link between the job/task analysis, objectives, and program design,
3. Attach associated information, like procedures, references, and equipment to tasks, objectives, and program design,
4. Flexible report generation format that allows the creation of custom reports and the revision of standard reports,
5. Handle both relational and hierarchical data,
6. Facilitate the effective and efficient application of the ISD process,
7. Provide security with password access to the database.

Currently, there are few off the shelf software packages that meet these requirements, but as the power of the integrated database concept takes hold in training organizations, there will be more and more to choose from.

Organizing the Database

Assuming the software is available, the structure of the database must be planned and organized. This means determining how the information should be structured so that useful training products can be generated directly from the database. This usually starts by making decisions about the basic components of the database. (For purposes of discussion, the basic components can be thought of as the job/task analysis, the objectives, and the program design.) Typical decisions about these

components include: how the job and task analysis will be organized, how the objectives will be organized, should conditions and standards be written with the objectives or should they come from a table, and how do objectives get sequenced into lessons. It is important to think about these issues at the start of a project so an efficient process can be set up to collect the appropriate information.

Then, decisions are made about the information that will be associated with the basic components. The types of associated information is usually derived from an examination of the existing training materials. For example, information on a job performance measure usually contains such items as a task statement, performance steps, conditions, standards, tools, equipment, and procedures, as well as a variety of standard text. This information is identified and decisions are made on how to organize the database to produce the job performance measure.

Once the database has been planned and important training products identified, the data is collected and entered into the computer. If the analysis and design data is being generated from scratch then different steps are taken than if it is generated from existing materials. Generally, when existing materials are used there are many inconsistencies to resolve.

In general, the process of organizing a database has the following steps:

1. Identify the desired outputs,

2. Identify the information needed on the outputs and specify an acceptable format,

3. Relate the information to the appropriate step in the ISD process,

4. Create a process to collect information,

5. Enter the data,

6. Create the reports.

This process is something new for most instructional designers. It requires a careful analysis of the information requirements of the training program and an ability to translate those requirements into a database structure that reflects the ISD process. This process is different from the traditional activities of an instructional designer, but is something instructional designers will become more familiar with as instructional databases become a reality in large training organizations.

Implementation Considerations

In order to make this approach successful there are several important management and organizational challenges that must be overcome. There has to be strong backing by management and a commitment to the integrated database concept. This leadership will establish the first project using this methodology as a high priority and secure and deliver vital resources to the project when necessary.

Several jobs in the organization will change significantly if this approach is implemented. For example, someone has to become responsible for the database. They will have to help set policies and guidelines about

the structure and content of the database. At a minimum this requires extensive knowledge of the software, the ISD process, and the ability to interact with instructors, subject matter experts and instructional designers.

The Future

If we are able to generate training products directly from one integrated database, then there are other important functions that could be added. For example it is possible to link a test generator to this database and use the objectives to help us write a bank of test questions. Furthermore we can use the structure of the training program to generate tests from the test bank. It also follows that you can track a student through the training program or manage student records based on the program design. In addition, we should be able to let a student into the database to down load lessons, job aids or JPMs right at their workstation.

Summary

We now have the technology to make analysis and design information much more useful than it has been in the past. But to realize these possibilities, we have to change the way we think about training information . The keys to making analysis and design information more useful are:

1. Knowing how to plan the structure and organization of a training database,

2. Having software that will handle the unique training information requirements,

3. Obtaining management commitment, a solid administrative plan, and new types of resources.

CURRENT TRENDS IN SYSTEMS DEVELOPMENT: THE EMERGENCE OF CASE TECHNOLOGY

Herman P. Hoplin

Abstract

With the current trend toward the use of Computer-Aided Software Engineering (CASE) in Systems Development and its related aspects of prototyping, end-user development, and code generators, the paper focuses on these rapidly emerging developments. CASE has become more and more vital to both large and small projects in both the Military and Civilian Communities. Industry encourages colleges and universities to develop software engineering programs based upon automated tools in Instructional Systems Development. Particular focus is on increasing the productivity of current and future software engineers. CASE technology is seen as one of the ways in which this can be accomplished. Now that the management of computerized information systems has become an integral function within the business establishment, it also is undergoing the same far-reaching transformations caused by computer automation. CASE tools are being designed with the business analyst in mind, not the programmer. An ideal set of CASE tools would not only help the user analyze system requirements and design the program modules to satisfy those requirements, it would also automatically generate the code, perform version-control and maintenance functions, and allow the user to extract any drawing or specification or code block from the database for inclusion in the documentation. For maximum versatility, the ideal toolset would allow the user to import data from or export data to other vendors' CASE tools and, by means of reverse-engineering techniques, help update existing programs and systems that were not originally designed with CASE. Unfortunately, the ideal CASE toolset does not currently exist. The author analyzes CASE as it currently stands; then looks at the benefits and drawbacks of CASE technology. Also addressed is what users are looking for in CASE and how they evaluate their current CASE applications. Finally, the author looks at the future of CASE, focusing on areas with high potential for CASE usage.

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CURRENT TRENDS IN SYSTEMS DEVELOPMENT: THE EMERGENCE OF CASE TECHNOLOGY

Herman P. Hoplin

INTRODUCTION

More and more, Computer-aided Software Engineering (CASE) tools are being designed with the business analyst in mind, not the programmer. An ideal set of CASE tools would not only help the user analyze system requirements and design the program modules to satisfy those requirements, it would also automatically generate the code, perform version-control and maintenance functions, and allow the user to extract any drawing or specification or code block from the database for inclusion in the documentation. For maximum versatility, the ideal toolset would allow the user to import data from or export data to other vendors' CASE tools and, by means of reverse-engineering techniques, help update existing programs and systems that were not originally designed with CASE. Unfortunately, the ideal CASE toolset does not currently exist. Considerable gaps in the sequence of CASE design remain and the necessary technology or industry-wide standard to fill these gaps is lacking. CASE tool vendors are well aware of these gaps and are working to develop more sophisticated tools to integrate these more closely.

At present, the CASE toolsets are strongest in the requirements-analysis and the module-design phases, the so-called front-end tools. Recently, reverse-engineering tools for the maintenance phases have started to become a reality. The biggest voids still show up in the code-generation phase and intertool communication capabilities.

All CASE toolsets provide a means for fully and accurately specifying what a software system must do. The system requirements phase is the key to success or failure. At this stage, it is feasible and relatively inexpensive to change the design to satisfy new customer requirements and to ensure that the logic of the design is correct and allows for future changes. The ease or difficulty with which you can make such changes depends on the complexity of the project.

In a large project, it is not easy for any one designer to grasp the whole picture of what the system must do. CASE tools allow as many people as necessary to work on different parts of the design; built-in functions check the completeness and consistency of each part of the systems requirements. Because CASE tools give you instant access to all sections of a design, you can review the interfacing information to ensure that your own section joins accurately and smoothly to other sections.

CASE, which was once the software developer's impossible dream, is now a reality. One practitioner states that CASE technologies are now becoming major productivity

enhancement tools for data processing organizations. (Clancy, 1989) CASE tools are currently available for a wide variety of computer systems, including inexpensive minicomputers such as IBM PC-clones. To facilitate different kinds of software design, the tools use different design methodologies. As CASE tools mature vendors are recognizing the need to develop interlocking tools to cover design and extend further into the life cycle. The underlying ideas of CASE are not new. They are an outgrowth of the philosophy of structured programming which has its roots prior to the 1960's in the teachings of Niklaus Wirth and Edsger Dijkstra. "Structured programming was the first effort at applying to software the principle of modularity and the use of independent, reusable building blocks, each of which performs a single function." (EDN, July 23, 1990, 225) This principle was already appearing in the construction of bus-based hardware.

The available CASE tools fall into two basic categories--first, tools that clearly define what a proposed software system will do; second, tools that specify the actual software modules for fulfilling these requirements. The modules can be converted to high-level codes. These two types of tools provide for consistency among different sections of a system regardless of how many people are developing the system. CASE software vendors adhere to a number of different schools of thought on how to implement these ideas.

Many of today's CASE tools offer you a choice among several design methodologies for two main reasons. First, such flexibility means that you will not necessarily have to learn a new methodology to be able to use a particular tool. Second, if you are already familiar with several methodologies and their notations, you can apply the methodology that best suits your problem.

CONCEPTS AND MISCONCEPTIONS OF CASE

Underlying CASE is the concept of software engineering which in turn is based on generally accepted engineering principles and practice. These principles emphasize formalism, standardized design, planning, and control in the developmental process. In addition to these basic engineering concepts, software engineering employs the application of design skills, good management practice, computer science, and mathematical formalism to the various facets of the software life cycle such as specification, design, verification, documentation, testing and maintenance. (Necco, et al, 1989)

It is critical to recognize that these techniques are performed within the context of a controlled, managed environment that promotes productivity, quality, and efficiency both in the short and long run. Integration of the related elements of management, planning, and development is also instrumental in software engineering. Problems are dealt within the bounds of rational holistic approach as opposed to a

piecemeal or reactive approach. By definition, any use of CASE necessitates adoption of this view.

Although the acronym is now widely accepted, CASE does not yet have a simple industry-wide definition. CASE tools have been defined as providing a means of standardization, discipline, and automation to systems analysis and application development. CASE is a combination of procedures, methods, and software tools that treat the entire application development process as a system that can be automated. These same principles that can be applied to an application system can be applied to managing the computer-based training design and development process. (Clancy, 1989)

Generally speaking, software *engineering is a means* by which an organization can choose an appropriate methodology for developing information systems spanning the range of the software life cycle from the strategic planning of systems to the enhancement of existing applications. It can be defined as "a series of orderly, interrelated activities resulting in the successful completion, delivery, and support of an information system--including programs, operating procedures and documentation." (Case, 1986) CASE is the technology that allows for automation of certain or potentially all endeavors that are undertaken within this framework.

The application of CASE to software engineering is directed at achieving several main objectives. It is geared toward increasing the productivity of all individuals involved in the engineering process including systems analysts, programmer, and MIS managers. It enhances the quality of the final software product and intermediate deliverables in the development process. Moreover, CASE provides for more effective management control over the development process.

Basically, a CASE tool should provide for a computerized mechanism for one or all of the activities commonly associated with software development. CASE tools that focus on the earlier stages of system development (e.g., planning, cost appraisal, structured design) are referred to as front-end products. Those tools that assist in the later stages of development (e.g., code generation, report writing) are known as back-end. CASE products that offer an integration of CASE tools affecting all stages of the life cycle have been named Integrated Project Support Environments (IPSEs) or, alternatively, Integrated Computer Software Engineering (ICASE). Regardless of which type of CASE a company chooses, emphasis must be placed on the comprehensive approach to systems development and maintenance that software engineering theory and practice requires. As CASE tools develop and mature, these tools will extend beyond design and penetrate deeper into the life cycle.

A CASE tool (or part of a comprehensive, fully integrated

IPSE) can also be classified in accordance to the general type of activity that it supports.. There are three basic activities that CASE tools can be used for: (1) strategic management and planning, (2) systems analysis/design and (3) programming (most commonly code generation driven by a structured specification language) and programming maintenance. Michael Gibson, Charles Snyder and R. Kelly Rainer have designated CASE support of these three activity groupings as 'Upper CASE', 'Middle CASE', and 'Lower CASE', respectively. (Gibson, et al, May 1989)

As might be expected given the high level of confusion surrounding CASE technology, there are many misconceptions concerning what it is and what it can do. Unfortunately, the lack of understanding of CASE tends to promote reluctance on the part of MIS to adopt it and can cause misjudgments to be made concerning its costs and benefits.

One of the more notable misconceptions is that CASE is a replacement of fourth generation languages. As noted above, CASE is available for use in areas other than programming. When it is used as a programming aid, system specifications are entered by the user and subsequently converted into either fourth or third generation code by the CASE system itself. Although sometimes referred to as a fifth generation language, CASE is not a substitute for existing languages.

Whereas CASE provides the greater ability to track project progress and to develop strategies and plans, it does not replace the vital function of leadership and direction on the part of management. A structured environment is still necessary. CASE can enhance effective management control, but does not eliminate the need for it. If anything, CASE requires a more disciplined set of procedures and standards than traditionally accepted. (Gibson, 1989, 14)

There is a tendency to believe that CASE eliminates the systems analyst. What CASE does is to give the analyst a set of tools from which to analyze and design systems and their specifications. It alleviates cumbersome paperwork and makes designs more malleable and can assist the systems analyst in responding more efficiently to unforeseen changes in design resulting from modifications in applications. The role of the systems analysts in the developmental process will be as central (if not more so) in the fully integrated CASE environment than in non-CASE situations.

The perception that the backlog of DP requests can once and for all be ended by employing CASE tools is erroneous. Even though CASE has the ability to deliver reliable systems and satisfy maintenance requests more efficiently, the sheer volume of increasing requests will not eliminate existing backlogs. Therefore, it would be overly optimistic for an organization to expect the backlog of developmental or maintenance

requests to diminish substantially with a fully integrated CASE system.

Some clarification is also needed when applying the terms CASE and ICASE. They are not one and the same as is sometimes thought. Integrated CASE (ICASE) encompasses all phases of software engineering, and more importantly, is the vehicle by which specifications are transported across these phases. Applications are formulated in the planning function in terms of general specifications of application systems to be developed. "Corporate IS planning specifications are translated into A & D (analysis and design) specifications for the applications. Systems analysts use middle CASE to add to these A & D specifications to more comprehensively describe the application. The design *specifications are translated into the* development specifications for programs within the application and necessary end user documentation. Systems developers (then) add to these specifications to provide a more comprehensive set of development specifications. Lower CASE systems then use these specifications to generate the programs within the application and accompanying end user documentation." (Gibson, et al, 1989, 12)

CASE, as opposed to ICASE, involves the automation of one or more tasks or set of functions that define one of the aforementioned phases. They operate independently, at least in the sense that they do not directly interface with other components except through manual efforts. A CASE tool that operates in a non-integrated situation is called a stand-alone CASE. The trend, however, is toward consolidation of CASE tools into a total comprehensive environment (i.e., ICASE) and away from segregated tools.

It should be recognized that CASE will not result in an immediate increase in productivity. There is a significant amount of overhead involved in starting up a CASE system. Documentation and specifications must be manually entered into a newly introduced CASE system. Determining the location of such documentation can be time consuming. In some cases, the documentation may not exist at all or may be scattered in many places and storage types from manual forms and documents to word processing files, and so on. Not until this type of start-up cost is completed can productivity gains from CASE even begin to be realized. Productivity will generally be increased over the long run; at that point the benefits may increase geometrically if CASE is employed properly.

ANALYSIS AND EXPECTATIONS OF CASE

Before the current status of CASE is analyzed, CASE must be further defined. Simply stated, CASE technology is the collection of tools designed to assist the system professional in his duties. These duties include all phases of the systems life cycle: analysis, design,

implementation, and maintenance. (McClure and Ambrosio, June 1989, 33-42) A CASE tool can be designed to help out in one, several, or all of these areas. Therefore, CASE tools can have a wide variety of functions, from simple data-flow diagram plotters to complex system code generations.

In this analysis, users' expectations of CASE systems highlighting what they feel are the most important factors in a CASE system will be addressed as well as a look at the current benefits and drawbacks of current CASE technology. The analysis will be concluded with an evaluation of how CASE technology meets up with users' needs and expectations.

In a recent survey of about 800 computer installations, the following were listed as the eight most important CASE tool features. Several conclusions can be reached from this data. First and foremost, users are concerned with the development of viable systems. Second, users desire tools that either deal with all aspects of the systems life cycle or work with other tools to create a total package. Finally, users are concerned with the functioning of the tools, desiring packages that utilize a methodology, have prototyping ability, and are well supported by the developer or vendor. The list of the eight most important CASE tool features follows: (McClure and Ambrosio, 9, 3, 1989, 33)

Checks Logic	96.3%
Supports Full Life Cycle	77.5%
Fully Integrated	74.0%
Prototyping Capab.	72.7%
Connectivity	71.0%
Contains a Repository	68.5%
Support/Training	67.3%
Uses Standard Technique/Methodology	66.4%

BENEFITS

One of the primary benefits of CASE technology is that it brings about the use of a standard methodology to all systems projects. When a systems professional uses a CASE tool or a set of CASE tools for his projects, all of those projects are developed using the same methodology as the tools will not allow steps to be skipped. (McClure and Ambrosio, March 1989, 34, 41) This kind of forced methodology results in a consistent product.

There is one major warning about this aspect of CASE tools: one must be very careful to match the methodologies employed by the desired CASE tools with the strategic direction of the information systems department and the overall information needs of the organization. (McClure and Ambrosio, June 1989, 40.) Many failures in CASE implementations have resulted from a failure to provide such a match. These mismatches can have a wide variety of results from systems that users feel uncomfortable with to systems that do not work at all.

There are several choices of methodologies that are currently available. One of the favorites is the traditional Process-Oriented

methodology as it is one that most systems professionals are familiar with and have had experience using. (Bailin, S. May 1989, 608) However, there are two new methodologies that are gaining in popularity for many applications: Information Engineering and Prototyping. Information Engineering is one example of a data-oriented approach to systems development. In this methodology, data design takes precedence over procedure design. First, logical models of the data used by the organization are developed. Then, individual application systems are developed using this model. In this manner, applications can be better integrated and data sharing can be better controlled. (McClure and Ambrosio, June 1989, 34, 41)

Prototyping is the development of an executable system that can model the functioning of the desired system. (Tanik and Yeh, May 1989, 9-10) This methodology is an iterative process with the prototype being continually adjusted and refined in response to the user's reactions. This process is continued until the model is found to be adequate to serve as the actual system. (McClure and Ambrosio, June 1989, 41) Prototyping is particularly useful in the development of systems that have a high level of user interfacing. (Rents, et al, May 1989, 59)

Another major benefit of CASE technology is the increase in the quality of code developed for a system. (Bouldin, August 1989, 30-39) One of the primary reasons for this is the automatic error checking features that are present in most code-generating tools. This increased quality results in fewer abends, fewer change requests by users, and fewer mistakes caught late in the cycle which can lead to enormous benefits. Another aspect of this benefit is an increase in code maintainability. (McClure and Ambrosio, June 1989, 41) Because CASE generated code is of a higher quality than traditionally generated code, it is easier to maintain. This is also due to the fact that CASE is generally better structured which makes it easier for the systems professional to look at a block of code and determine what it is doing.

One possible downside of this benefit is that although code is generally being generated better, it is not necessarily being generated <u>faster</u>. However, this is not seen as being a drawback of CASE tools. According to Pam Fox of Lincoln National Corporation, "(we are not) as concerned with productivity as we are with quality. We want to give (developers) tools that will help them do their jobs better, not faster."

Another benefit of CASE tools is the development code that will be reusable; i.e., code that can remain fundamentally unchanged each time the system is modified or restructured. Not only the code becomes reusable but the existing software offers a way to achieve lower development costs as well as quality for these new software products. Many believe that the promise CASE tools have in this

area is far brighter than the actual progress achieved to date. According to Adrian McManus of American Express, "The real benefits will come with truly reusable code that can be saved at a higher, more abstract level--entity relationship models and data flow diagrams." (McClure and Ambrosio, June 1989, 41) However, code generated from a CASE system still has a greater potential for reusability than traditionally generated code because of its higher quality and easier maintainability so this can still be listed as a benefit.

DRAWBACKS

The major drawback of CASE technology is the lack of industry standards for the interfacing of various CASE tools. This lack of a consistent applications interface has hurt CASE as it makes it difficult for the systems professional to use a group of tools from different vendors to develop a single system. According to McManus, "I don't know anyone . . . who is completely satisfied with any one tool. So, you have to buy different vendor's tools for different phases. Vendors will have to come to grips with (interfacing) their products." (McClure and Ambrosio, June 1989, 40) This lack of interfaceability puts the systems professional in a dilemma. Either he uses a single total life cycle tool for a development that does not do everything the way he would like it to or he uses the best tools for each aspect and had to deal with trying to integrate the tools. Clearly this is an issue that must be resolved in order to make CASE a truly useful technology. One notable exception to the existing situation is KnowledgeWare's "Application Development Workbench (ADW)" which is a comprehensive collection of CASE tools integrated through an Artificial Intelligence (AI)-based repository. (Application Development Workbench, 1991, 2)

Another drawback of CASE is that there is a significant learning curve inherent in the technology. Typically, there is a two-project learning curve where productivity is very low. Only after these first projects does CASE technology begin to approach the productivity of the previously employed technique. (McClure and Ambrosio, June 1989, 41) However, despite the learning curve, CASE tools still produce a product of high quality and reliability right from the start.

A third drawback of CASE technology is the cost involved with a CASE implementation. To start with, there is the initial cost of the CASE software and the hardware to run it on. This is not all the costs. In addition, there are the training costs associated with the CASE technology which have been estimated as being about three times as much as the cost of the software. (McClure and Ambrosio, June 1989, 43)

Because of this significant capital requirement, CASE tools are frequently avoided by organizations that look only to immediate benefits, rather than long-term returns. As the majority of CASE benefits occur

in the long run, the technology tends to look bad when evaluated in this manner. Only organizations that understand the future value of CASE technology tend to overlook this drawback.

EVALUATION

In an evaluation of CASE tool performance, one must first look at how users tend to benchmark CASE effectiveness. In a recent survey, experienced CASE users ranked three decision criteria with the following results: (Bouldin, August 1989, 31)

Primary Criteria:

Time Savings:	47.5%
Quality Improvements	39.2%
Financial Savings	13.3%

Secondary Criteria:

Time Savings:	38.8%
Quality Improvements	36.9%
Financial Savings	24.6%

Tertiary Criteria:

Time Savings:	13.8%
Quality Improvement	21.4%
Financial Savings	61.9%

When viewed in this light, CASE technology looks pretty good. CASE technology offers significant time savings once the learning curve has been overcome and it has a proven record in the area of code quality improvement. Although CASE technology's financial savings can be in doubt, particularly in the short run, this is not a significant problem as this aspect is not viewed as being as important as the other two.

Another way to evaluate CASE technology is to look at it in terms of the eight important features that were previously discussed. In this manner one can evaluate how CASE is meeting users' needs rather than how users evaluate CASE.

In terms of four of these major features, CASE is currently performing very well. As was discussed in the benefits section, CASE tools generally check logic providing the user with high quality code. CASE tools also can have very good support and training, but the user is going to have to pay for these features. Because of the nature of their design, proper use of CASE tools will provide the user with a standard methodology for all projects, and, if the proper methodology is selected, CASE tools can provide excellent prototyping capabilities.

However, in terms of three of these major features, CASE is currently not performing up to the users' expectations. As was discussed in the drawbacks section, although many CASE tools support the full development life cycle, the performance of individual elements of these tools is usually not up to the users' standards. Also, with the exception of vendor development such as KnowledgeWare's ADW cited previously, CASE tools are poorly integrated and vendors currently offer little connectivity with other vendors' tools.

The last of these major features, the utilization of a repository, really does not fall into this evaluation. If a repository is important to an individual user, he should limit the decision set to CASE tools that have this capability. Otherwise, a user is free to choose from all the available tools.

To conclude this evaluation, it appears that CASE tools are meeting the users' expectations and requirements fairly well, but there still is room for significant improvement. CASE tools are very strong in many of the technical aspects of the systems development process. However, they are still very weak in one major area of importance to the user: integration and connectivity. In order for CASE tools to be truly viable in the future, it is very important for this area to be addressed.

FUTURE OF CASE

As has just been discussed, CASE, although an impressive technology, still has some problems to be worked out in order to make it truly invaluable to the systems professional. These problems are not necessarily insurmountable, but they do represent some of the major barriers against universal CASE adoption. However, if these problems are solved, there are many areas that will be of future consideration to the CASE technologist.

In this section, we will go over some of these areas: Prototyping, Expert Systems, Project Management, and the trend to go Back to the Basics. They represent some new applications of CASE technology, some expansions and modifications of existing applications and one possible threat to CASE.

Prototyping. As previously mentioned, prototyping is the process of developing a scaled-down version of a system to use in building a full-scale system. (Tanik and Yeh, May 1989, 9) Although prototyping is a currently utilized methodology in CASE technology, it still is an area of massive potential for the future. There are three areas of prototyping that are believed to have a large growth potential: Software Evolution, Object-oriented CAD, and Software Storming.

Software evolution refers to all activities that alter a software system, including requirements changes, performance changes, and repair. Essentially, it is systems maintenance in it broadest scope. It is a very important consideration in systems development, as software evolution accounts for more than half of the total software cost. (Luqi, May 1989, 14) It is hoped that this would result in a much lowered software evolution cost because of this ease of maintenance.

Object-oriented CAD is truly a hybrid technology as it represents the application of CASE technology to the field of circuit design. It follows CASE technology in that it allows designers to gradually refine a

subset of operations rather than developing a complete application. (Gupta, et al, May 1989, 28) It also involves the development of improved software tools for hardware testing. (Davidson, April 1989, 12) It will be of increasing interest in the future as it allows for a convergence of knowledge between software and hardware developers.

Software storming is another hybrid technology as it represents the combination of knowledge engineering (the brainstorming problem solving technique) and systems development technology. Using this method, a team of researchers developed in four months a software prototype with significantly more functionality than a conventional prototype that took two years to develop. (Jordan, et al, May 1989, 39) This area represents a major breakthrough in shortening the amount of time required to develop a system.

However, there are five considerations to be looked at before attempting to implement such a technique. Know the problem: software storming is not appropriate for ill-defined or broadly focused problems. Know the team: Storming requires tremendous cooperation between team members as the team must quickly adapt to changing roles during the storm. Know the tools: if unfamiliar tools are being used, time will have to be allotted to develop expertise in them. Know the data: every aspect of the data environment should be understood. Finally, document in video as videotapes of the storming sessions are particularly useful in catching the developed techniques. (Jordan, et al, May 1989, 47)

Clearly from the above considerations, software storming is not a universal solution to systems development problems. However, its massive potential for high productivity in certain situations makes it something that should be considered for the future. Perhaps further research in this area will result in techniques that are more readily applicable to common situations and still give improved results.

Expert Systems. Expert systems are another area that has potential to reap enormous benefits from CASE technology. Traditionally, many of the most successful expert systems were developed by a trial and error methodology. It is felt that taking a more structured approach in the development of expert systems will allow the designers to avoid the mistakes of the past. It is hoped that CASE technology will become this structure. One of the major reasons that this would be possible in the area of expert systems is that 50% to 75% of the work in designing a system is traditional systems development. (Blackman, February 1990, 27, 31) Perhaps the first Expert System connection development of intelligent user interfaces for decision support tools, such as databases and decision models, is in analogical reasoning systems or model reasoning. This is CASE-based reasoning ongoing research in intelligent problem formulation. (Blanning, October

1990)

Project Management. One of the biggest problem areas in MIS is project management. There are horror stories of numerous incidents of runaway development projects which have adversely affected budgets, reputations, and even competitive capabilities of the companies involved. (Levine, March 1989, 32) The integration of project management techniques into CASE methodologies would help control many of these projects.

It is becoming increasingly clear that management wants software developers to have the same sort of accountability that other functional areas have for their projects. They are tired of treating systems development as an art and want to see some traditional management techniques applied to it. It is felt that the application of such techniques would have the following results: (Jordan, et al, May 1989, 34)

1) Risk reduction in planning
2) Management acceptance
3) Early performance analysis
4) Control over developers' activities
5) Control over configuration of modules

Software developers also realize the need for controls over the development process. It is felt that the application of project management techniques would improve the overall coordination and performance of a development team. A survey of developers revealed that they desire many of the traditional features of project management, including: (Gupta, et al, May 1989, 32-33)

- o Critical path scheduling
- o Cost and schedule integration
- o Time-phased quantity and budget reporting
- o Resource summarizations
- o "What if" analysis capability

This is an area that can be addressed by CASE technology. CASE, because of its methodological basis, already contains much of the structural design of a project management system. It is just a matter of merging these two areas to make a simple consolidated product that can handle total life cycle design and project management. Currently there are many systems that purport to offer CASE project management (Levine, March 1989, 35-38) However, because of the current lack of integration between CASE tools, most of these packages cannot satisfy the requirements of both the developers and management. It is for this reason that project management is considered an area for future development in CASE. It is hoped that once the integration problems are solved, we will be able to develop truly useful CASE tools that will satisfy everyone.

Back to Basics. One trend that CASE technology must look out for is the desire on the part of both systems professionals and users to move back to a more simplistic process with greater user involvement. (Synoradzki, September

1988, 30) This trend, if it is realized, could greatly affect the future of CASE technology. It is felt that developers of CASE tools should keep this in mind as they make the tools of the future.

Perhaps the development of more end-user oriented CASE tools is in order. A similar development occurred when spreadsheet programs brought significant computing power to the hands of the end user by simplifying the process of generating financial and other number-intensive applications. This, however, could be considered a good possibility as CASE tools tend to be very complex instruments, similar to many accounting programs that were very complex until the development of Lotus 1-2-3.

CONCLUSION

In summary, since the arrival of improved microcomputers in the mid-1980's, CASE tools have become the dominant trend in systems development. They encompass many of the other trends such as prototyping and code generators. CASE tools also come in a wide variety of capabilities from simple data flow diagram plotters to total life cycle packages.

User expectations of CASE tools are very high and are currently being only partially met. Benefits include standard methodology, increase in code quality, and the development of reusable code. Drawbacks of CASE include lack of integration of tools, a high learning curve, and high costs.

CASE technology is facing many opportunities for further development in the future. The decade of the '90's can be viewed as the beginning of the third generation of CASE. There are many areas that can be further developed, including Prototyping, Expert Systems, Project Management, and Repository Products. However, CASE developers must also be aware of the possible trend of bringing more computer power directly to the end user.

Organizations around the world are now using CASE. CASE tools have been around for more than five years with more than a dozen companies in the CASE business. We now have established guidelines for evaluating CASE tools and know the right questions to ask in advance for determining wise choices.

In conclusion, CASE is a technology that is truly at a critical point in its development. It has had some degree of success, but it still has much potential that it has to live up to. As CASE technology matures, it is expected that it will become an even more dominant trend in software development of new systems and a positive force in renewing the effectiveness of aging systems. Now that the CASE vision has been created, its universal acceptance requires selling it through education.

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A COMPREHENSIVE ENGINEERING APPROACH FOR INTELLIGENT TRAINING SYSTEMS

Wendy Sallman
Robert Jancoski

FMC, in cooperation with Virginia Polytechnic Institute, developed the Hoist Trainer for use with the FMC manufactured Mark 45 naval gun. The Mark 45 is a complex weapon system that consists of 15 major assemblies; one assembly being the lower hoist.

To learn the hydraulic operation of the lower hoist, the primary instruction aid used in the classroom today is a schematic drawing. Teaching the hydraulic operation of a weapon system with a static schematic can be difficult and time-consuming because this approach relies heavily on the student's ability to conceptualize operation s/he cannot readily observe. To help students understand the hydraulic operation of the lower hoist, FMC developed the Hoist Trainer.

The Hoist Trainer is a computer-based training system designed to teach students the hydraulic and mechanical operation of the Mark 45 lower hoist. The trainer features a qualitative model of the lower hoist, a counterfactual inference engine, and a schematic-based user simulation. Computer-based training offers the benefits of consistency, easy distribution, and improved student performance and retention.

The innovative technical concepts represented by the training system are applicable to any hydraulic/mechanical system. In addition, the system components can extend into other application domains such as model-based diagnostics or intelligent tutor systems. This paper discusses the Hoist Trainer architecture, lessons learned during development, FMC developed software tools that will aid in the engineering of future training systems, and the applicability of Hoist Trainer concepts to other applications.

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A COMPREHENSIVE ENGINEERING APPROACH FOR INTELLIGENT TRAINING SYSTEMS

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Mark 45 Lower Hoist Background

The Hoist Trainer has been developed for use with the FMC manufactured Mark 45 naval gun. The Mark 45 is a complex weapon system that consists of 15 major assemblies with over 23,000 parts. One major assembly of the gun is the lower hoist. This assembly functions as the transfer mechanism of the gun that delivers ammunition from its storage room to its ready magazine. The ammunition within the lower hoist rests on pawls that are attached to a hydraulic rack. The entire lower hoist transfer mechanism is controlled by solenoids that convert electrical signals to hydraulic pressures.

The lower hoist consists of approximately 150 elements or parts. These elements include: seven types of pistons, three types of latches, two types of solenoids, four types of state-detecting switches, a chain, a linkage, a hydraulic rack, a clutch mechanism, and hundreds of hydraulic pipes.

To understand the operation of the lower hoist or any weapon system often requires the student to derive the operation of the system, using hand-colored schematic drawings. This approach to learning weapon system operation is usually time-consuming and difficult and does not ensure depth or consistency of training. To allow students to systematically learn the operation of the Mark 45 lower hoist, FMC developed the Hoist Trainer.

Hoist Trainer

The Hoist Trainer is a model-based training system designed to teach students the internal operation of the Mark 45 lower hoist. The Hoist Trainer offers the benefits of computer-based training: consistency, easy distribution, and improved student performance and retention.

The Hoist Trainer simulates the ammunition load and off-load operations of the lower hoist. Both processes involve six operational machine cycles:

1. engage coupling
2. rack extend
3. drop engage coupling
4. disengage coupling
5. rack retract
6. drop disengage coupling.

The Hoist Trainer is deployed on the Texas Instruments microExplorer. The system architecture consists of three major components, each having specialized, but interrelated duties: a qualitative model, a counterfactual inference engine, and a user view that includes a schematic-based simulation and an intuitive user interface. These system components are discussed in the following paragraphs.

Qualitative Model

The qualitative model of the Hoist Trainer was developed by Virginia Polytechnic Institute (VPI) and funded in part and extended by FMC's Naval Systems Division [1,2,3]. The model uses qualitative physics to predict and explain the behavior of the lower hoist in qualitative terms. Qualitative reasoning is used to derive the normal operation of the lower hoist from a structural model. The lower hoist structural model consists of elements, a representation of element behavior, and the connections between elements. Elements within the Hoist Trainer can be described as mechanical, hydraulic, or electrical parts (e.g. pistons, solenoids, pipes).

The connections between the elements in the Hoist Trainer are typically hydraulic pipes. The connections are governed by the principle of locality and are expressed as causal relationships. The principle of locality states that a single causal relationship can only influence the behavior of its neighbors. No one element can have direct influence over the behavior of the entire machine [1,2,5].

Counterfactual Inference Engine

The second component of the Hoist Trainer is the counterfactual inference engine. This engine was developed by VPI and funded in part by FMC's Naval System Division [3,4,5]. The counterfactual inference engine operates on the qualitative model to create a current world

or a representation of the lower hoist operation that is consistent at a fixed point in time.

For example, assume the qualitative model and the engine have created a world that represents the engage coupling cycle. In this scenario, the world is represented by the state of lower hoist elements (the pistons, solenoids, etc.) at the start of the engage coupling cycle and the causal relationships that connect the elements.

To cause the engage coupling cycle to be advanced to the next cycle of operation, the rack extend cycle, a counterfactual is introduced. A counterfactual is a piece of knowledge, or a fact, that contradicts at least one believed state of the current world. For the purpose of our example, assume the counterfactual represents a solenoid that changes from the current not energized state to the energized state. This solenoid state, when introduced into the current world, distorts the world and creates a world that is inconsistent. The counterfactual inference engine uses the counterfactual, "solenoid energized," and assumes that it is true in order to generate and propagate all possible sets of lower hoist machine states that would explain or make a consistent world. In other words, the counterfactual inference engine works with the qualitative model to create a world that makes sense for the "solenoid energized" counterfactual. The resulting world is again consistent and represents the next cycle of lower hoist operation - rack extend. The representation of this world is a list of lower hoist machine states. FMC uses this list of information to drive the schematic-based simulation of the Hoist Trainer.

<u>User View</u>
The user view of the Hoist Trainer is an important component of the training system. A typical student does not care about the underlying technologies or the system architecture. The student is mainly concerned with how to use and understand the system. Using this knowledge of the student or user, FMC developed a user view for the Hoist Trainer that consists of two subcomponents: a user interface and a schematic-based simulation.

User Interface
The user interface is the student gateway to the Hoist Trainer. Its intuitive design allows the student to experiment with the training system through self-explanatory, pull-down menus and dialog boxes. This approach to user interface design allows students to work at their own pace and to tailor the instruction to their own needs. Individualized training allows students to explore only what they need to know, without repeating concepts they have already mastered [6].

Four user menus were developed to allow the student to control the execution of the Hoist Trainer: Control, Mode of Operation, Load and Off-Load.

The Control menu provides the student with an option to take single steps, forward or backward, through the current cycle. For example, the student could step backwards through the rack extend cycle to visually review why a lower hoist element changed state. In contrast to single step control, the control menu contains an automatic option which allows the student to observe the mechanical operation of an entire cycle. Reset and quit menu selections allow the student to restart the simulation and exit the application, respectively.

The Mode of Operation menu allows the student to select and view the execution of the load or off-load operation of the lower hoist. Depending upon the mode of operation selected, the Load or Off-Load Cycle menu is enabled.

The Load Cycle and the Off-Load Cycle menus, are similar in structure. The lower hoist operation for each of these cycles includes the same cycles, but the cycles occur in a different order The cycle menus let the student advance the model to any cycle of operation to experiment with the training system. This allows the student to examine the operation of the lower hoist elements as the ammunition is loaded or off-loaded from the storage area.

Schematic-Based Simulation
The Hoist Trainer simulation was derived from hand-colored schematic drawings. FMC developed a set of graphical icons and arranged them on the computer screen to resemble the

original schematic drawing. These icons were developed using a modified Steamer environment [7].

Color was incorporated to distinguish different hydraulic pressures. The color scheme selected was representative of the scheme used by field service technicians. Red was used to depict high hydraulic pressure and yellow was selected to represent low hydraulic pressure. The icons were linked to the simulation lists produced by the counterfactual inference engine and the qualitative model to produce a simulation that animates, step by step, the mechanical and hydraulic operation of the lower hoist assembly.

Lessons Learned

When FMC originally developed the Hoist Trainer, a system developer had to handcraft all the graphical elements of the lower hoist. Each graphical element of the simulation contains two parts: a view describing how the component is displayed on the screen and the design or structural knowledge that describes its physical states. Writing this code for every element of a hydraulic/mechanical system can be a very time consuming and tedious task! In order to develop future systems comparable to the Hoist Trainer in a cost-effective manner, tools must be developed to automate the creation of qualitative models and the display and operation of graphical icons.

Software Tools

FMC's objective with respect to software tools was to allow system developers to concentrate their efforts on constructing the appropriate solution for a problem rather than being burdened with the "mechanics" of developing the underlying software. To accomplish this objective, software tools were developed to help build future applications cost effectively. To aid in the development of future training systems, FMC began the development of two editors: the Icon Editor and the Connection Editor.

Icon Editor

The Icon Editor was developed to allow a developer to systematically build the graphical elements needed to simulate the operation of a mechanical system. Currently, the Icon Editor is a generic drawing editor that allows for the selection of the basic geometric objects. Icon Editor functions were developed to manipulate the objects and ease icon development and placement on the computer screen. The result is a generic drawing editor suitable for creating graphical icons for model-based or simulation training applications. Source code generators designed for the Icon Editor will automatically produce LISP code for the graphical representation of an icon or schematic-based element, as well as produce code for the qualitative model representation.

Connection Editor

The Connection Editor complements the Icon Editor. The Connection Editor allows for the interactive specification of the hydraulic connections drawn by the Icon Editor. Using the Connection Editor, a system developer can methodically create, with a mouse and pull down menus, the hydraulic connections for the graphical simulation. An integrated source code generator creates LISP code for the graphical display thus freeing the developer from this tedious task. The result is a generic software tool that reduces developmental costs for future training systems.

Other Applications

The technical concepts represented by the Hoist Trainer are generic and applicable to any mechanical/hydraulic system. For example, within the FMC product line, training applications could be developed for the Mark 13 missile launcher or for all assemblies of the Mark 45 naval gun.

The architectural components of the Hoist Trainer can extend to other application domains such as model-based diagnostics [5] or Intelligent Tutor Systems (ITS). The Hoist diagnostic application uses the qualitative model, the counterfactual engine, and the schematic-based simulation. The qualitative model works with the counterfactual engine to create a list of possible suspects. The suspect list is linked to the schematic-based simulation to give the user a visual depiction of the diagnostic process highlighting the suspect elements.

The qualitative model and the user interface also contribute to the development of a lower hoist intelligent tutor system. The qualitative

model makes up the domain knowledge of the ITS and the schematic-based simulation is used to communicate lower hoist operation.

Outside of FMC, applicable application areas include aircraft, automobile, and submarine systems. The qualitative models developed for these applications could use the counterfactual inference engine, since it is a general-purpose inference engine suitable for solving many types of problems. The technical concepts represented by the qualitative model of the Hoist Trainer are also generic. The qualitative representation of a piston in one training system will require a similar level of abstraction in another application. The user interface is applicable to other intelligent training systems because the simulation of normal operation is a natural way to communicate the underlying technology to the student.

Conclusion

The Hoist Trainer is an intelligent computer-based training system designed to help students learn the internal operation of the Mark 45 naval gun. The concepts implemented in the training application are generic and applicable to any mechanical system. FMC software tools, with designed source code generators, ease the development of future intelligent training applications and offer a comprehensive software engineering approach for the development of intelligent training systems.

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TAILORING EXPLANATION TO USERS

Anat Jacoby

To understand how to tailor expert system explanation to users, a study was conducted that examined the effects of goals and explanations on different task performance. Fifty-four high school students were randomly assigned to one of two explanation groups or a control group. All groups received the same purpose/goal of needing to replicate a scheduling task of assigning flights to gates in an airport. All groups received a sample schedule, and the explanation groups received in addition one of two explanations, a retrospective-trace explanation or a reconstructive-justification explanation. The retrospective-trace explanation provided the detailed steps of how to construct a schedule; the reconstructive-justification explanation provided justification of a given schedule. All groups received two tasks, in random order: a replication task of producing a schedule and a verification task of verifying the correctness of a schedule. In addition, a questionnaire was given to determine the students' satisfaction from the explanations. As predicted, students getting the retrospective-trace explanation performed better on the replication task than the two other groups. These preliminary findings suggest that explanation should be tailored to people's goals that reflect the tasks they need to achieve.

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TAILORING EXPLANATION TO USERS

Anat Jacoby

Expert systems are becoming more and more popular in various areas, both as on the job tools and for education. One feature thought to be central to the success of expert systems is their ability to offer explanations of their knowledge and reasoning. Explanation is essential for understanding, debugging, education, acceptance, and persuasion. The artificial intelligence (AI)/expert system community has been researching techniques to build explanation facilities for expert systems. Several techniques have been developed and explanations in the form of software have been built. Many researchers agree that it is important to tailor the explanation to the user, but the approaches taken to implement this purpose vary.

It seems likely that whether an explanation will be useful or not will depend upon factors such as the type of explanation provided, the nature of the task, and the ability and goals of the user (Berry & Broadbent, 1987). Most existing reports, however, consist of informal information from users. Researchers usually develop a technique and build the explanation facility without studying it with people. This study was conducted to investigate the results of using two different explanation approaches on different users. The main objective was to try to "fit" the explanation to the users by trying different explanations with users having different goals before implementing the explanation facility.

The first part of this paper will discuss different explanation techniques developed by artificial intelligence/ expert system researchers, and different characteristics of expert system users. The study and the hypotheses will be introduced followed by methods and results sections where detailed discussion will be provided.

Explanation Facility Techniques

The most common technique used for developing an explanation facility is what Waterman (1986) describes as retrospective reasoning. mxetrospective reasoning involves tracing through the rules ofmxhe expert system to provide the user the line of reasoning that the expert system used in its solution. The chain or sequence of rules that led to the conclusion is provided. Early systems like MYCIN (Buchanan & Shortliffe, 1984) give the information stated in the expert system rules translated to English. More advanced systems attempt to adapt the explanation to the user by providing an interactive dialogue with the user (Moore & Swartout, 1989), tailoring the explanation to the user's "point of view" (McKeown, Wish, & Matthews, 1985), or phrasing the text to the user's level of expertise (Bateman & Paris, 1989). Although the above systems vary in their emphasis, all share the general approach to

explanation of following the system's line of reasoning. They all provide a trace of the steps the system followed to arrive at the solution.

A different approach to explanation development was taken by Wick and Thompson (1989, 1990). They believe that the "line of explanation" should be different from the "line of reasoning". A technique was proposed named "reconstructive explanation" which uses knowledge other than the trace as the basis for the explanation. The explanation does not give the details of how the system arrived at its conclusion but rather justifies the solution by giving reasons why it is the correct one. For example, in explaining the cause of an excessive load on a concrete dam, rather than following the reasoning path that led to the solution of erosion, a reconstructive explanation moves directly to erosion and explains the relationships that bond the symptoms directly to erosion, and introduces new data that was not included in the solution trace. This type of explanation, according to the authors, is more appropriate for many users of expert systems. Again, this technique has been implemented in a prototype expert system, but its effects on performance have not been tested.

Expert System Users

Researchers believe that there are several overlapping reasons for wanting an expert system to explain its reasoning. These are: understanding, debugging, education, acceptance, and persuasion. These reasons were suggested by Buchanan and Shortliffe (1984) and are cited by many other explanation facility researchers. These points will be further explored in an attempt to understand who are the typical users of an expert system and its explanation.

Understanding implies understanding the content of the knowledge base and of the line of reasoning. Understanding is important for both maintaining and using the system. Explanation is needed for debugging, as expert systems are usually built incrementally. Debugging is done by expert system builders and maintainers. Education is needed for nonexperts using the system since users who feel they learn something by using the system are likely to use it again. Acceptance refers to convincing potential users to use the system, and persuasion refers to convincing users that the system's conclusion is correct. Acceptance and persuasion are closely linked and apply to people who are potential or actual users of the system.

Two types of users are reflected from the above description; they are usually referred to as "knowledge engineers" and "end users". A knowledge engineer is one who builds the system and maintains it. An end user is the person using the system. The knowledge engineer needs the detailed information of how the system arrived at its conclusion in order to debug and expand the system. The end user typically uses the expert system as a consultant program and needs to understand its reasoning well enough to be able to accept responsibility for the solution. Both users need the explanation facility

but their goals for needing it are very different. While the knowledge engineer needs to understand the process of replicating the solution, the end user is interested in verifying the solution only. The end user does not need the information of how exactly the system arrived at its conclusion. Moreover, this information might confuse and overwhelm the end user. The end user only needs and wants information that will persuade him or her that the solution is correct. The knowledge engineer, on the other hand, needs all the steps of how the system reasoned, starting at the very beginning and following every trial to the solution.

The proposed study suggests two different lines of explanation to these two different users having different needs and goals.

The Study Two different kinds of typical users were identified: knowledge engineers and end users. These two user types were also identified as having different goals: replication vs. verification. The knowledge engineer is interested in replication knowledge while the end user is interested in verification knowledge. Two kinds of explanation techniques were introduced: retrospective and reconstructive. The goal of this study was to check whether the two kinds of explanation match the two kinds of users. It was believed that since the retrospective explanation provides a detailed sequence of the steps taken towards finding a solution, this kind of explanation will be appropriate for replication. The reconstructive explanation, on the other hand, gives a justification for the solution, without going into the details of the process used to arrive at the solution. This explanation was believed to be more appropriate for verification purposes.

This study checked the influence of the replication goal and the different explanations on user's satisfaction and performance. Another study needs to be done to compare the differences in satisfaction and performance between verification goal and replication goal.

The purpose instruction given to subjects in this study was believed to direct their attention to information relevant to the task to be done at the end of the treatment. The different tasks were replication and verification. The replication task asked subjects to solve a problem by carrying out a procedure. The verification task asked subjects to verify the correctness of a solution to a given problem. Two kinds of explanation were given as treatments. The first, a retrospective trace, stated a general problem and showed the procedure for solving it including false trials. The second, reconstructive justification, stated a solution to a problem with a justification but did not specify all the details of the procedural process needed to actually solve the problem. A control group received no strategic explanation only the information needed to solve the tasks. The domain chosen for the study was that of assigning airplanes to airport gates after they have landed.

Hypotheses It was hypothesized that the group getting the replication purpose with the retrospective trace explanation would perform better on the replication task than all other groups, since the goal, the explanation, and the task "match". It was also hypothesized that students receiving the replication purpose would be more satisfied with the retrospective trace explanation.

Finally, the study was conducted because its results may have implication for developing good explanation facilities for expert systems as well as for teaching and explaining. Implications for teaching and explaining may be for deciding of whether to provide purpose/goal statements, and for gearing an explanation to one's purpose/goal. For the area of expert systems and explanation facilities although the study was a pencil and paper study rather than an actual working expert system, it can provide theoretical framework for building an explanation facility.

Pilot Test A small pilot test was conducted using as subjects a graduate and three good high school students attending a private high school. The purpose of the pilot test was to check the measures and materials as well as the time needed for task completion. The graduate student was pilot tested first and then materials and measures were changed since the decision was made to conduct the study in a high school with time limit of one class session. The pilot study's results showed that the fifty minutes available would be sufficient and the instructions were clear. Subjects only looked at the explanation briefly and then proceeded to do the task, going back to the explanation as needed. Therefore, the students in the study were given specific time to read the example and explanation before doing the task. All high school pilot subjects did the replication task with no mistakes, and two pilot subjects had one mistake in the verification task, the third had no mistakes.

Subjects Fifty eight male and female students from a Los Angeles public high school participated in the study. Four of the students who were not proficient in English were excluded from the study analysis. The students were tenth, eleventh and twelfth graders that were enrolled in one of the three classes: basic math, geometry, or year book. The study was completed during regular class time. The students were informed that they were participating in a study and to increase their motivation to participate and do well their teacher told them they would get credit for participating. All students received the replication purpose and were randomly assigned to one of the explanation groups or the control group.

Experimental Design The design of the study consisted of two explanation groups and a control group. There were two dependent measures which were given after the treatments and were given in a random order so

all together there were six different groups: Retrospective trace explanation - verification task first (TV), retrospective trace explanation - replication task first (TR), reconstructive justification explanation - verification task first (RV), reconstructive justification explanation - replication task first (RR), control group - verification task first (CV), control group - replication task first (CR). Students were randomly assigned to treatments within classrooms.

All subjects received the same purpose/goal instruction of replication; i.e. that they will be getting an example and explanation of how to schedule airplanes to gates and would be required to do a similar task.

The explanations given to subjects were: retrospective trace, reconstructive justification, or no explanation. The retrospective trace explanation included a problem and the procedure to solve the problem; starting from the problem and working towards the solution. Different hypotheses and attempts for solutions were given even if they did not lead to the correct solution. The reconstructive justification explanation included a problem, its solution and an explanation which justified why the chosen solution was the correct one given the information and constraints or rules. False attempts to the solution were not mentioned.

Explanation

	Retrospective-trace	Reconstructive-justification	Control
Replicate Purpose Instruction	Verify first TV	Verify first RV	Verify first CV
	Replicate first TR	Replicate first RR	Replicate first CR

<u>Procedure</u> The subjects were told by the experimenter that they would solve a problem as part of a research study and that they would get credit for participation. The experimenter explained the nature of the task of assigning airline flights to gates after they have landed. The students were told that they would be getting different tasks and therefore to work individually. Subjects then received their material and were given five minutes to look at the first packet which included an example and the appropriate explanation. This was done to insure that the students read the explanation before attempting to complete the tasks themselves. Then, students were asked to solve the two tasks and fill out the steps taken to solve the tasks and the questionnaire. The experimenter checked that all parts were completed when the students handed in their forms. The study took one class period of fifty minutes all together, including the experimenter's explanation.

<u>Materials</u> All subjects received two packets of material. The first packet included the flight scheduling restriction, an example, and for the explanation groups- the appropriate explanation. The second packet included the replication task, the verification task, and a questionnaire. Following each task a worksheet was given and a sheet to report the steps taken to solve the problem. The packets were clipped together so that the second packet was up-side down. This was done since the students were asked to read the explanation first and only start working on the tasks when instructed. Further descriptions of the materials are provided below.

The domain chosen for the study was the scheduling of planes to gates in an airport. Airlines have specific gates in airports that they can use for their flights. The airline is responsible for scheduling incoming and outgoing flights to the gates. There are certain rules and constraints to follow while doing this task. One constraint is that there are different sizes of aircrafts and different sizes of gates and the sizes need to match, i.e., one cannot assign a big aircraft to a small gate.

Another constraint is that incoming international flights need to be assigned to a gate that is in the customs area since passengers need to go through passport check and customs on their way into the country.

Ground controllers are responsible for this gate assignment task. An expert system was developed to help ground controllers in this task. The expert system was developed for TWA, for JFK and St. Louis airports (Brazile & Swigger, 1988, 1989). The system does not currently have an explanation facility in it.

This task was chosen since it represents a problem solved by expert systems and is a task that can be replicated (to make a schedule) and verified (to check the schedule) by a subject pool without specialized domain knowledge. The domain is simple to understand since it uses everyday language and terminology. The task, although simple, is one most people haven't attempted.

All students received the same purpose statement and the same restriction list and sample schedule. The purpose statement given to all subjects was the replication purpose/ goal. All subjects were told they would be receiving an example and explanation and would later have to complete a similar task themselves. The objective of the purpose statement was to manipulate subjects' purpose/goal of why they were receiving the information and explanation that they were. Another study should be done to check the verification purpose.

The standard materials included a page of flight scheduling restrictions, an example, and for the explanation groups, the appropriate explanation. The flight scheduling restrictions included gate restriction, i.e., domestic and international gates, and separation time between two different flights using the same gate; plane type restriction, i.e., five different plane types and what domestic and international gates they could be assigned to; and taxiway access restriction, i.e., what different taxiway exists and what gates they lead to. The example consisted of ten incoming flight information and the gate the flights were assigned to. The format of the example was identical to the format of the tasks. The explanations were given to the appropriate treatment group and provided an *explanation of the* example. The control group received no explanation.

Dependent Measures Subjects completed two tasks: a replication task and a verification task, and a questionnaire. The replication task provided a list of flight information that included the following facts: whether the flight was domestic or international, plane type, flight number, arrival time, and departure time. An empty column was given for the subjects to fill in the gate assignment. Subjects were asked to schedule ten flights to the appropriate gates without violating any of the constraints. A worksheet was provided, and a sheet asking subjects to report the steps they took to solve the task.

The verification task provided a similar list of flight information and also included the same facts of whether the flight was domestic or international, plane type, flight number, arrival time, departure time, and the gate assignment. For this task the gate assignment was given and subjects were asked to verify the schedule for ten flights and circle flights that violated restrictions. Of the ten scheduled flights given, three had the wrong assignment that were due to violating different restrictions. There was a worksheet and a page to write down the steps taken to solve the problem similarly to the replication task. The tasks were paper and pencil tasks.

The questionnaire asked all subjects whether the explanation they received was helpful in doing the replication task or the verification task, and why. The questionnaire also asked if the example and explanation were helpful in achieving the stated goal. General questions were also asked about sex, year in school, GPA, and domestic, and international travel experience.

Treatment Description There were two kinds of explanations: retrospective trace and reconstructive justification. The retrospective trace explanation explained to subjects how to make a schedule by starting at the information given of flights, gates, and constraints, and trying to assign flights to appropriate gates. The explanation included strategies such as assign all big planes first, and leave gates that are close to customs for incoming international flights etc. The explanation demonstrated how the example schedule was put together showing false trials as well. That is, a flight might be assigned a gate and then needs to be reassigned because of a different flight coming in with more restrictions. A graphic table was shown and explained. The table had a horizontal column of the available gates with the matching taxiways, and a vertical column of the times. Lines were drawn to show the gate was occupied at a given time. The table provided a visualization strategy of solving the task.

The reconstructive justification explanation justified the example schedule by explaining that it fits all the rules and constraints. There was not a specific explanation of the process taken to arrive at the solution, and false trails were not mentioned.

RESULTS The verification and replication tasks were checked for correctness. The recorded score represents the number of mistakes made. The two tasks were very different in nature and therefore no comparison can be made between the tasks, only between the experimental groups among each task. Table 1 shows the means and standard deviations of both tasks for each experimental group.

Table 1

Performance on the verification and replication task of all explanation groups

Explanation		Verification task	Replication task
Retrospective-trace verification first	M (SD)	1.57 (0.54)	3.14 (0.38)
Retrospective-trace replication first	M (SD)	1.89 (0.60)	2.00 (1.34)
Reconstructive-justification verification first	M (SD)	1.57(0.54)	3.43 (0.79)
Reconstructive-justification replication first	M (SD)	1.89(0.99)	3.40 (1.27)
Control verification first	M (SD)	1.90 (0.74)	3.00 (1.41)
Control replication first	M (SD)	1.57 (0.79)	4.44 (0.52)

Note: The scores represent the number of mistakes made.

A two way ANOVA that checked the effects of the explanation groups and the order showed a significant explanation (group) main effect, no order main effect and a group by order interaction for the replication task (see table 2). No significant main effects nor interactions were found for the verification task.

Table 2

ANOVA table to show explanation group main effect and group * order interaction for the replication task

Source	df	Sum of Squares	Mean Square	F
Grp (exp.)	2	15.72	7.86	6.60*
Order	1	0.26	0.26	0.22
Grp * Order	2	15.22	7.61	6.39*
Error	48	57.19	1.19	
Total	53	88.15	1.66	

Further analysis showed that, as hypothesized, there was a significant difference between the groups in the replication task. A post hoc Tukey comparison showed that the significant difference was between the retrospective-trace explanation group and the reconstructive-justification explanation group, and between the retrospective-trace explanation group and the no explanation control group. Students who received the retrospective-trace explanation performed better (made fewer mistakes) on the replication task. No significant differences occurred between the reconstructive-justification explanation group and the control group. These results demonstrate that the retrospective-trace explanation was the appropriate explanation for the replication task.

Although not hypothesized, data analysis also checked for differences among the groups in the verification task. No significant differences were found among the groups, despite the different explanations received.

The ANOVA also showed a group by order interaction. There was a significant difference for the replication task in the retrospective-trace explanation and the control group. While in the retrospective trace explanation students who received the replication task first did better than students receiving the replication task second, the opposite occurred in the control group. For the verification task, although not significant, the results indicated that the students receiving the reconstructive-justification explanation performed better on the verification task when receiving it first, while students in the control group performed oppositely.

Three classes participated in the study. A two way ANOVA found a significant difference among classes on their performance on both tasks (see tables 3 and 4). There was no interaction with explanation, and therefore these results are assumed to occur from the different abilities of the students in those three classes.

Table 3

ANOVA table to show class main effect for replication task

Source	df	Sum of Squares	Mean Square	F
Grp (exp.)	2	16.52	8.26	6.74*
Class	2	12.65	6.33	5.16*
Grp * Class	4	4.84	1.21	0.99
Error	45	55.17	1.23	
Total	53	88.15	1.66	

Table 4

ANOVA table to show class main effect for verification task

Source	df	Sum of Squares	Mean Square	F
Grp. (exp.)	2	0.07	0.03	0.10
Class	2	8.12	4.06	11.64*
Grp * Class	4	1.26	0.32	0.91
Error	39	13.61	0.35	
Total	47	23.00	0.49	

A two way ANOVA was done to check for sex differences. There were no significant sex differences.

Chi square tests were conducted to check the questionnaire answers. Most students recorded that the explanation they received helped them to do both tasks, and matched the goal they received. There were no significant differences among the explanation groups in the way they answered the questionnaire.

DISCUSSION This study examined the effects of students' goal and the kind of explanation received on their performance on a replication task and a verification task. The goal of the study was to better understand how expert system explanation can be tailored to users. As predicted, students who received the replication goal and the retrospective trace explanation performed the replication task better than the group getting the reconstructive-justification explanation, and the control group receiving no explanation.

To understand further the effect of both the goal and the explanation on users a study needs to be conducted where a verification goal is given to half of the subjects. It is predicted that these subjects getting the verification goal and the reconstructive-justification explanation will do better on the verification task than all other subjects.

There was no significant differences in the performance on the verification task among the explanation groups in this study. To further understand if this was due to the explanation or to the goal being a replication goal, a study should be conducted with another domain and another explanation. It is possible that the verification task might have been too easy and subjects could perform it regardless of the kind of explanation they received.

Another interesting finding was that the order in which the tasks were given resulted in differences in performance. While subjects who received the task that matched their explanation first (replication task for retrospective-trace explanation, and verification task for reconstructive-justification), did better than subjects receiving it second, the control group did better on that task when receiving it second. The author's explanation to that is that when the explanation matched the task it was more helpful to do the task right away than get another task in the middle. For the control group, though, who received no explanation, the practice of doing a task helped on the second task.

Altogether, the results do show that a goal and different explanations do effect subjects' performance on replication and verification tasks. Further research needs to confirm the findings and make them more specific. The results are applicable to both classroom teaching and to writing good explanations in expert systems. To make the results more applicable to the different areas further research needs to be more specific and in real life settings and situations. That is, for applications in teaching, real classroom situations need to be examined so that students actually hold the goals to be manipulated, and need to do the actual tasks. Similarly in the expert system's domain, a computer should be used instead of paper and pencil, and different expert system's users rather than high school students should serve as subjects.

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Development of the Media Elimination and Design Intelligent Aid

Dr. William T. Melton

Abstract

The Training Development and Analysis Directorate of the United States Army Training and Doctrine Command (TRADOC) has developed an expert media selection system and design aid to assist soldiers assigned to develop training in making critical design decisions.

The Media Elimination and Design Intelligent Aid (MEDIA), which will be demonstrated assists training developers by recommending media and other design elements to be used in teaching specific tasks or learning objectives. Media, methods, site, learning strategy, categories of learning, and learning activities are selected based on requirements related to the task or objective. The model lists all of the media which provide acceptable levels of fidelity and interaction. The acceptable media are compared and prioritized on three ordinal scales reflecting procurement, development and implementation costs.

This paper presents the general logic that supports the programming of these design decisions based on a limited group of questions which are primarily related to the nature of the task or objective being learned and the general characteristics of the soldiers to be trained. Several of the decision relationships differ significantly from those presented in the traditional instructional systems development model.

Author Biography

Dr. William T. Melton is an Education Specialist assigned to the Training and Doctrine Command, Fort Monroe Virginia. He is responsible for writing the guidance pamphlet on the Design Phase of the Systems Approach to Training, for developing the expert system for media selection and for teaching Planning, Resourcing, Analysis and Design in the Training Developer Middle Managers' Course. Prior to his assignment at HQ TRADOC he was the primary instructor for the Training Developer Course at the Combined Arms Training Activity, and held various positions at the Army Air Defense School including Chief of Analysis, Chief of SQT and STP Development, and Chief of Program Management. He served eleven years active duty as an Engineer Officer. He holds a Doctor of Education Degree in Adult Education from Texas A & M University where he published a report of study on media selection in the Army.

DEVELOPMENT OF THE MEDIA ELIMINATION AND DESIGN INTELLIGENT AID

Dr. William T. Melton

Background

The establishment of a systematic process of making critical design decisions concerning media, methods, learning strategy, site selection, categories of learning, and events and activities has for many years been a major concern for military training developers. The Army has purchased and used a variety of paper-based systems and job aids to help developers to make these decisions. These have been used with varying degrees of success.

The development of an automated system to provide assistance in making these decisions has been considered and attempted several times. Some of the early systems, either provided matrix type templates for the developer to use in creating his own decision making system or were oriented more toward audit trail (decision rationale) data storage than decision making assistance.

The advent of expert and artificially intelligent systems has encouraged the consideration of other alternatives for providing decision making assistance to the training developer. Several expert systems for media selection have been developed in recent years. Those surveyed tended to have very limited media arrays or expressed possible proprietary bias. This paper will present the general logic supporting the decision making aids incorporated in an expert system developed by the Training Development and Analysis Directorate of the Army Training and Doctrine Command (TRADOC) specifically designed for military use.

Description of the Media Elimination and Design Intelligent Aid (MEDIA)

MEDIA is a computer expert system designed to assist training developers in selecting media, methods, learning strategy, site selection, categories of learning and events and activities. Recommendations are made in each of these areas which will meet all of the training design requirements of the task or objective to be trained.

Developers using the program are asked a series of questions about the task or objective for which they are designing training. MEDIA uses the answers to these questions to eliminate media and methods which cannot provide the required cues, practice, interaction or other characteristics. MEDIA also uses these same questions to recommend training sites, learning strategy, categories of

learning involved and guidelines for appropriate events and activities.

Media and Method Recommendations

Media and method recommendations are based on a series of questions primarily about the nature of the task or objective. The system does not assume that the user has expertise in training design or development. To enable the system to be used effectively by persons who are not trained in education, the questions intentionally avoid addressing the training requirements. This choice was made because many of the persons charged with making media and method decisions are technical subject matter experts who are very familiar with the task but are not professional trainers.

The questions are therefore structured to elicit information specifically about the performance of the task or objective related to:

1. the type of performer,
2. the type of task,
3. the interaction required,
4. the type of cues,
5. the physical and mental skills required,
6. the use of job aids, and
7. the task characteristics.

The MEDIA program does not try to select a single best medium or method for each task or objective. Rather it provides the training developer recommendations from which to choose. Based on answers to the questions, developers are provided cost-ordered lists of media and method lists for each of the four primary levels of training. These four lists reflect media and methods appropriate for the introduction, mental practice, competency evaluation, and sustainment of training of the task or objective.

The media are listed in logical cost order from the least to the most expensive. Three ordinal scales from one to seven are used to assign logical comparative costs to each medium presented for its procurement, development and implementation costs. A development time value of less than six months, more than 6 months or more than 2 years is also given for each medium listed. The comparative costs and time estimates are presented to help the developer to make final media selections from among the media presented in the lists.

Learning Strategy Recommendation

The program recommends one of the six learning strategies available to the Army based on the level of inter

activity needed to effectively train a given task.

Review of the six primary learning strategies available for use in military training revealed that they could be related to each other by examining the change in the student teacher relationship. This relationship provided a scale of changing levels of live personal human interaction.

The six learning strategies considered listed in order of increasing human interaction are programmed learning, traditional learning, exercise or experimental learning, small group learning, pure group process learning, and mentor learning. Because the system user is often not a trained educator, descriptions of each of these are presented to the user as they are recommended.

The program asks the training developer three primary questions to determine the level of interaction needed (thereby determining the particular learning strategy needed). These questions pertain to the experience level of the trainee, the level of commitment required of the graduate, and the anticipated level of resistance to the training. Increasing experience, required commitment and potential resistance to the training all resulted in an increased need for live human interaction. The cumulative effect of these is used to recommend learning strategies with an appropriate level of live human interaction.

The learning strategy with the least acceptable level of live human interaction is the one presented to the user as the system recommendation. The presentation of the recommendation is followed by a statement that any strategy with a higher level of human interaction is also acceptable but will probably be more resource intensive.

The incorporation of a learning strategy model is a change from previous systematic design systems. It is included because the Army has experienced several periods of change in which new learning strategies were adopted as a replacement for a previous strategy simply to find that they did not solve the problem. Each learning strategy has an appropriate use with a particular level of student. The failure of strategies resulted from attempting to use them for training a group which was not appropriate for the strategy. The model is designed to help training developers to match learning strategies to the appropriate levels of student need for live human interaction.

Site Recommendation

The training site recommendation is made based on the elimination of less resource intensive sites. The sites are considered and selected beginning with the least expensive location and continuing to the most expensive. The less expensive location is only eliminated if the answers to the questions asked by the system indicate that it is not usable.

These sites are eliminated through rather direct questions on:

1. the practicality of using job aids,

2. the ability of the unit (job site) to provide the support necessary to train the task,

3. the requirement for proficiency in the task on initial unit (job site) assignment, and

4. the necessity for an on site instructor to evaluate or to provide for safe training.

Some questions on the characteristics of the task are also used in making the site selection recommendation.

This is a departure from previous site selection systems used by the Army which were geared toward identifying reasons the training should be done at the school. Recommending the school only if the training cannot be done elsewhere follows a logic pattern borrowed from the British Army system for site selection and is much more realistic in times of constrained training resources.

The training site recommendation is presented with a question allowing the user to choose or override the recommendation. This is done because the selection of the primary training site, the site where competency evaluation will occur, will effect the media available for use.

The sites listed for selection include:

1. job aid in the unit or living area,

2. distributed sites,

3. unit (job site) facilities,

4. school facilities, and

5. dedicated permanent facilities.

The site selected will appear as the site for the competency evaluation level of training. Other sites may be recommended for the other levels of training if they are possible and less resource intensive than the site chosen for competency evaluation.

Categories of Learning and Recommended Events and Activities Guidelines

The questions related to the mental and physical skills required for the task or objective list verbs associated with the three categories and eleven subcategories of learning. The categories of learning are physical, mental and attitudinal. The eleven subcategories included in the system are:

1. rule learning,

2. classifying patterns,

3. identifying symbols,

4. detecting,

5. making decisions,

6. recalling bodies of knowledge,

7. performing gross motor skills,

8. steering and guiding,

9. positioning movement and recalling procedures,

10. voice communicating, and

11. attitude learning.

Those subcategories which are related to the verbs the user selects as characteristic of the task or objective being evaluated are listed on a screen at the end of the program.

The system recommends that the user use the subcategories of learning listed to enter the guidelines and flowcharts in the user's manual provided with the system. The selection of the appropriate guidelines and flowcharts will provide the user with a tested structure of activities useful in providing an effective program for that specific mental or physical skill. If many subcategories are listed the user may use these to create logical enabling objectives with which to reenter the system for a more refined set of design recommendations.

Summary

The primary purposes of this design aid are to save training developer time, to eliminate costly mistakes, to support the effective distribution of training and to recommend the lowest cost strategy, media, site and method which can be used to effectively train the task or objective.

With shrinking resources the military training developer will be pressed to produce more training products in a shorter period of time. Training developers will no longer be able to simply follow the latest technological fad or "do it the way we always did it" as a quick solution to design decision making.

The military services have already experienced an adequate number of excursions into media which did not produce the results expected. It is more important than ever that training developers systematically tie media and design decisions to the characteristics of the task or objective.

The cumbersome paper based systems of the past simply take too long to implement to support the design decision making of the future. The shear number of relationships, available media and design alternatives make the creation of new paper based design decision systems unworkable.

The design decisions in MEDIA were based on these four principles.

1. The ideal strategy, method, site, and media combination is an expert performer/teacher with a single student, training on the actual equipment in the job performance environment. All training designs are attempts to simulate the ideal in progressively constrained environments. Media are therefore at best an extension of this kind of live human interaction to meet the needs of larger numbers of students at lower resource expenditure.

2. Many different media, methods, and strategies can effectively train parts of almost any task. Training experts can rarely agree on a single "best" medium, method or strategy for training any specific task or objective. Most media, methods and strategies can be distributed to multiple locations.

3. The major criteria effecting media method and strategy selection can be grouped under the consideration of fidelity, interaction, and cost. The lowest cost medium and strategy that will meet the fidelity and interaction criteria associated with the task should be the first recommended solution. The low cost design solution should be recommended to conserve resources to support tasks and objectives requiring greater levels of fidelity and interaction.

4. Any training media selection for the military should consider the needs of the active and reserve components, mobilization, unit training and sustainment of proficiency.

INFORMATIONAL FEEDBACK AND CONCEPT LEARNING
IN COMPUTER-AIDED INSTRUCTION

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Feedback during student practice is considered a fundamental component of well designed Computer Aided Instruction (CAI). This study investigated the effects of three levels of feedback to student responses to practice questions and a second attempt to answer the practice question in a CAI lesson. The lesson taught a new concept, basic navigation. The subjects were 173 college freshmen at the Academy. Significant results were found for providing the learners a second attempt to answer the practice questions on their acquisition and retention tests and for the increased levels of feedback to error in answering their practice questions on their retention test.

Lieutenant Colonel Nielsen graduated from Texas A & M University, with degrees in Political Science. After initial aircrew assignments in B-52's, he was assigned to the USAF Academy. During his first tour at USAFA, he was an instructor and then course director for the senior military studies course as well as the Chief of Evaluations for Military Instruction. He was also a T-43 navigation instructor and a Cadet Squadron Training Officer. He returned to USAFA and his current duties after a doctoral program in Instructional Technology at the University of Texas, Austin.

INFORMATIONAL FEEDBACK AND CONCEPT LEARNING IN COMPUTER-AIDED INSTRUCTION

Introduction

One of the events of instruction (R. Gagne, 1974) which poses great potential for a robust application within CAI is feedback (Brophy, 1986; B. Cohen, 1985; Kulhavy, 1977). Generally, feedback in CAI is an imbedded software reaction to the learner's responses to questions or situations. Feedback could take the form of auditory, graphic, or textual messages. Many aspects of feedback have been researched, however many believe it to be one of the weakest areas of instructional software (G. Cohen, 1983; J. Merrill, 1987; Cohen, 1985; Komoski, 1984). In fact, the research results only seem to confound the dialogue (Jonassen, 1988). Part of the problem may be the diversity of the approaches taken in the study of feedback. Feedback has been examined for its ability to reinforce, to inform, to identify errors, and to correct errors. It has been researched in relationship to other factors such as cognitive level of the instructional objective, different learner

characteristics, and level of learner control. A brief examination of the research from these perspectives is helpful.

Early views of feedback came from the operant conditioning school of behavioralist psychology. Feedback was reinforcement used to strengthen correct responses. Positive reinforcement was a pleasant stimulus given immediately after a correct response. However, later research, conducted by those who ascribe to the cognitive school of psychology, dispute the effect of reinforcement. Robert Anderson, theorized that the assumption that KCR was a reinforcer was based on an analogy to food or water deprived animals. If KCR was reinforcing, then a delay in KCR should interfere with learning. Research by the author and by other investigators showed delays improved retention (R. Anderson, Kulhavy, & Andre, 1972). Other researchers could not confirm the reinforcement aspects of feedback and did find that feedback acted primarily to correct errors (Guthrie, 1971; Roper, 1977).

Many cognitive psychologists embrace the belief that some feedback does reinforce, but informational feedback primarily serves to help students locate errors and provides information to help learners

correct their errors (J. Carter, 1984; Shimmel, 1983). In fact to some researchers, the number of errors corrected is directly related to the amount of information in the feedback (Roper, 1977).

The possible forms of informative feedback can range from simple to complex. The most basic provides the learner only with information about the correctness of the response and can extend to the point where the amount of information surpasses the information provided in the original instruction. Several researchers have provided generally accepted definitions of the levels of informational feedback: (a) Knowledge of Response (KOR), which informs the learner whether the selected response was correct; (b) Knowledge of Correct Response (KCR), which informs the learner of the correct response; and (c) Knowledge of Correct Response plus additional information which details why the correct answer is correct or why the incorrect answer is not correct (Gilman, 1969a). Gilman (1969a, 1969b) calls the later type of feedback Response Contingent feedback. Several other variations exist: (a) KCR plus an explanation of why the selected incorrect response was wrong or why the correct answer was correct; (b) KOR plus information explaining why

the incorrect response was wrong or why the correct answer was correct; and (c) hints which direct the learner to the correct answer based on stimulating recall of information already provided in the initial instructional sequence. The research literature provides comparisons of the effects of varying combinations of the different levels of informative feedback. Typically, enough variation exists in the combinations of the levels of feedback, even without considering other variables, to preclude accurate comparison of results from the study. In several different studies which compared an explanation with KCR and KOR, researchers found that the explanation was best, followed by KOR and KCR (V. Cohen, 1985; Gilman, 1969a, 1969b; Kulhavy, 1977; Roper, 1977).

Different levels of feedback seem to effect learning differently, relative to the different types of learning outcomes. Grant, McAvoy, and Keenan (1982) found that feedback explanations which focused on the relevant critical attribute of a concept was the most effective feedback in concept learning.

Other factors or levels of feedback have been examined. For example, hints have been the focus of instructional design and feedback research. Jay

(1983), in his recommendations for feedback in courseware design, proposed the use of hints to sharpen a close response or to lead the learner to the answer without outright giving the answer. When discussing CAI instructional design considerations, Smith and Boyce (1984) recommend the use of clues (hints) in feedback which could be either learner requested or provided automatically by the software. Feng and Reigeluth (1983) compared hints, KCR, and KOR. A hint was information designed to help the learner select the correct answer based upon the instructional information already presented in the software. They found that hints, then KCR, followed by KOR, tended to elicit the best posttest scores.

Another possibility in the practice and feedback section of CAI which received some attention was to provide the student a second attempt to answer the question after an error (Noonan, 1984; Smith & Boyce, 1984). Again, when discussing feedback in the instructional design of CAI, Smith and Boyce (1984) state that one of the values of the CAI environment was that learners could be allowed several attempts after incorrectly answering a question. Noonan (1984) investigated the impact of a second attempt after two

different types of feedback when learning procedural objectives in a CAI program.. Noonan found no significant differences between groups. However, he recognized that current statistical methods do not evaluate the different posttest successes relative to an improvement based upon treatment. Again, the research is not consistent because of the wide variety of uncontrolled and dissimilar secondary variables which do impact results. Many of these research studies conflict with on another, leaving the educator to choose on result or the other, thinking the studies examined the same questions under similar conditions and received contradicting results. It appears more work needs to be done in the research of feedback.

The diversity of the research results on feedback is potentially confusing. Four factors, when combined, highlight the differences in research results. The function of feedback, the taxanomic level of the learning objective, the focus on correctness and the integration of learning theory and cognitive memory theories all play a part in determining the most appropriate feedback to use. The general recognition that feedback has two functions, error correction and confirmation or reinforcement, (Kulhavy, 1977; Roper,

1977) is one factor. Researchers often do not clarify which function they are evaluating, and they seldom design materials and dependant measures which differentiate between the two factors.

A second factor which will help clarify the results is recognition of the fundamental relationship between the feedback and the learning objectives (Sales, 1988; Maher, 1985; Schimmel, 1983; Reiser & R. Gagne, 1982; Snyder & Land, 1988) and the subsequent design and report of research project with that relationship clearly identified and controlled. For example, the cognitive level of the objective should have significant impact on feedback. Schimmel (1983) and Reiser and Gagne (1982) found that more informational feedback was increasingly helpful in higher levels of cognitive material. Therefore, the feedback used to successfully learn a new concept should be different than the feedback use to learn new verbal information.

The next factor emphasizes the need to focus on the correctness of the answer. The researchers in verbal learning (Kulhavy et al., 1985; Siegel & Misselt, 1984) and those in concept learning (Shoen, 1972; Gilman, 1969b) identified informational feedback to be more

beneficial when expressed as a condition of the correctness of the right answer. Feedback which concentrates on the student's error may have leave the student thinking about the error; this subsequently increases the likelihood that they remembered the incorrect solution. Going deeper into the theories, Thorndike's (1932) Law of Exercises and John Anderson's (1976, 1983a) theory of reinforcement and strengthening propositions could apply. The proposition, which represented the incorrect solution that the learner selected was activated and consequently strengthened, while the correct proposition was not strengthened. This would also partially explain the success of KCR in verbal learning, the correct proposition, restated in the KCR, was strengthened. The use of a second attempt also takes advantage of the same strengthening of the correct propositional bonds.

A final factor integrates the ideas of Robert Gagne (1965a, 1965b, 1987), Tennyson (1980, 1984), and John Anderson (1974, 1983a, 1984) and provide a theoretical explanation which integrates the different results regarding concept learning. There are differences in how verbal information and subsequent concepts are stored (J. Anderson, 1974, 1983a, 1984). The

integration of their ideas, to some degree, is a building block approach, just as each researcher built on the developments of his predecessors, and just as Robert Gagne (1965a) explains that learning verbal information is necessary for learning concepts. Verbal learning, memorization of terms or words, for example, is the foundation for a concept. This is also consistent with taxonomies of the cognitive domain being proprietary and hierarchical. An abstract concept might be learned through attribute listing (Tennyson, 1980, 1984; Tennyson & Park, 1980). Integrating the ideas of Tennyson, Robert Gagne, and John Anderson might provide a clearer view of abstract concept learning. The verbal information, stored as a proposition which forms a propositional network (J. Anderson, 1974. 1983a, 1984; R. Gagne, 1987). Those propositional networks are arranged to build a production (J. Anderson, 1974, 1983a, 1984) which is the attribute list described by Tennyson (1980, 1984) necessary for concept acquisition, especially for abstract concepts. Informational feedback provides information to correct the production. Informational feedback can add, remove, or rearrange the order of the propositions in the production, especially while still

located in STM. While KCR is enough information to correct the error in a proposition, or the verbal information, it may not be enough to correct the order of the propositions in the production which in turn describes a concept. This would explain the reported success of KCR in concept learning. When the error is in the proposition, the verbal information level, and not the production, KCR is enough feedback. Informational feedback goes beyond KCR because it provides the corrective information necessary to correct the production, and ordered propositional network. This seems most applicable to abstract concepts, but the integration of theories also explains how concrete concepts may be created in human memory.

In addition, the descriptions of concrete concepts versus abstract concepts could be reflected in John Anderson's alternate method for storage in memory, images. Consequently, a reason for the success of prototyping theory, is that a verbal picture or an actual picture, the prototype is used to develop a concrete concept in memory.

Method

Subjects

The subjects were 173 freshman college students at the United States Air Force Academy. Entry requirements place these students in the top quarter of the class of college freshman nationally.

Materials

The computer program used to present the lesson was a researcher-designed program based on a linear format. The program was compiled in Turbo-Pascal for a 80286 microprocessor based computer system with 512K RAM, EGA screen, and two 360K floppy disk drives or one hard disk with 720K of memory free. No other materials were required.

Three fundamental concerns prompted the selection of the subject. A major factor in the study was the need to teach a new subject to the learner, but one that they were motivated to study. Secondly, the learning objectives were from the concept level of Robert Gagne's (1974) taxonomy. It was also preferable that prerequisite fundamental knowledge or discriminations necessary to learning the concept were covered in the CAI lesson so errors in prerequisite

knowledge did not impact on concept attainment. Finally, a large number of learners was needed, as the collectable data was based on feedback provided on error. Unless the material was unreasonably difficult and didn't reflect the level of materials typically expected for the academic group. Without a large group, there would not have been many errors, hence there would have been little data to analyze. Navigation, a required course for all students, as a good candidate. Few high-school students study navigation

A linear program format does not take advantage of the computer's capability to branch within a program and to repeat a block of instruction based upon learner request. However, computer based software was necessary to evaluate the media and it provided easy control for time-on-task, access to knowledge level information, number of attempts, and several other factors which might confound results.

Procedures

The experimental procedure followed a pretest, intervention, and posttest sequence. The pretest and delayed posttest were conducted as a computer base exercise, identical in format to the practice questions

and the immediate posttest. The intervention containing the treatment and the immediate posttest was conducted as a CAI lesson in a computer laboratory.

The participants were administered a computer based pretest. The students met in their regularly scheduled classroom and then were directed to the lab, where the pretest was conducted at the beginning of the regularly scheduled class. The participants were randomly assigned to one of six treatment groups, stratified on pretest score. While all students completed the intervention, however, only subjects with pretest scores less than eighty percent were considered in the analysis.

When subjects arrived at the computer lab for instruction a system was available for every subject. Each system contained an identical copy of the instructional software and the pretest score-treatment group data base on the hard disk. The system accessed the data base and presented the instruction with the appropriate randomly assigned treatment. The instructional software recorded the start time from the computer. Once the student has completed the instruction the computer recorded the subject's completion time as well as the stop and start time for

each objective. The student was presented with the posttest. Once complete, the software saved the SSAN, pretest score, treatment group, total time, time by objective, responses with an identifier for a correct or incorrect response for both first and second attempt if applicable, and posttest score in the data base on the hard disk.

The students attended their next regularly scheduled class. At the beginning of the class, the students were again moved to the lab and received an unannounced posttest on the computer. It followed the same format as the pretest, the instruction, and the immediate posttest. Their delayed posttest scores were added into the data base.

Analysis

Results

For statistical analysis, ANCOVA was used with attempts and level of feedback, the two independent variables, as categories. The percentage of first attempt errors on the practice questions was the covariate. For level of feedback on the immediate posttest, the F-ratio was not significant at $p \leq 0.05$. In contrast, level of feedback on the delayed posttest was significant at $p \leq 0.01$. For one versus two

attempts on the immediate posttest and on the delayed posttest the results were significant at $p < 0.006$ and $p \leq 0.046$ respectively.

Discussion

Significant results indicate that a second attempt to answer practice questions which were missed on first attempt has an impact on acquisition and retention of a new concept. This confirms the intuition of many classroom teachers and instructional designers, as well as the theoretical foundation established by Thorndike (1932) in his Law of Exercises and John Anderson's (1976, 1983c) theory of reinforcement and strengthening propositions. These findings partially support the design recommendations of Smith and Boyce (1984) who stated that one of the values of the CAI environment was that learners could be allowed several attempts after incorrectly answering a question. It would be inappropriate to extend the findings of this study past a second attempt, but it showed significant results for one additional attempt to answer a practice question in concept learning.

Like second attempt, the increase in the level of informational feedback showed significant effects on retention. This again supports the theoretical

framework of this study and complements the research on feedback by Gilman (1969a) in which increased information was identified as beneficial to retention and by Feng and Reigeluth (1983) who focused on hints.

Unlike the effects found on retention, as measured by the delayed posttest described above, the effect of levels of feedback on concept acquisition, as measured by an immediate posttest, were not significant. Further examination of the data showed that the posttest mean of KOR1 was 86.25; for KORI1 it was 86.714; and for KORIH1 it was 83.037. The results were almost directly contrary to prediction, however the results were similar to those of Hodes (1985) and Kulhavy, et al. (1985).

Interviews with the students in each treatment group, may have identified the reason for these seemingly anomalous results. Students in the treatment group which received only Knowledge of Results (KOR) feedback were very unhappy that they did not get any extensive feedback. When asked why they were upset, they stated that they had to work hard in the beginning, when the initial instruction was being presented, so they could do well on the exams. The students in the Knowledge of Results plus Information

(KORI) and Knowledge of Results plus Information plus Hint (KORIH) groups said they liked the feedback because they could breeze through the initial instruction, thus saving time. If they made an error, the feedback would save them because it focused on the attributes of the concept they did initially acquire. The ability to save time was emphasized by the students who received KORIH. The hint helped them focus on the part of the correct answer they had missed.

R.C. Anderson, Kulhavy, and Andre (1971) identified this as "short-circuiting" instruction with feedback. In their study which used KCR after teaching a medical concept, the researchers emphasized two possible explanations for the potential failure of KCR. The first was short-circuiting the instruction. The students were able to find the correct response to the questions in the feedback, so they chose any answer, read the feedback, and selected the correct response. Their second idea highlighted a feature of human nature which may have motivated the short-circuiting, that is, the law of least effort, which functions when students are tired or under pressure. When students knew KCR was available, they studied less carefully or spent less time in the primary instruction.

In the case of this study, the short-circuiting of the instruction with the feedback may have been counter-productive to accurate results. If the students' objective was to answer the test properly but as easily as possible, the feedback was ideal for short-circuiting the instruction. The learner could move quickly through the primary instruction, selected their best choice, and the feedback would identify and correct the misunderstanding if an error was made. The feedback in the ungraded practice questions focused on the correct attributes of the correct answer to the practice questions. The hint was even more focused on the correct answer. The practice questions were similar to the posttest, so the students could expect do well on the posttest. Second attempt students were then able to confirm their selection. The short-circuiting may have been a learning strategy they developed in the past to compensate for poor instruction or to save time. This student sub-population was selected to attend the Academy because of its record of academic capability and its success. The possibility exists that these subjects short-circuited the instruction, hence the results, in their attempt to ensure success with relative ease.

Instructional Design

The results of this study could be interpreted to mean, that if one is a good designer, and one wants his or her students to do the best possible job of acquiring and retaining a new concept, one should use the highest level of feedback, knowledge of results plus information plus a hint, with a second attempt. The use of second attempt is a simple and effective tool to improve acquisition and retention and should be included. However, the more sophisticated the level of informational feedback, the more work, hence higher development costs, are involved. Adding higher levels of instructional feedback involves significantly more work than including a second attempt.

If the analysis of the learner in the design process shows high end academic achievement, it may be appropriate to let the learner choose the level of feedback, particularly if retention is not a concern. In fact, since the student may short-circuit the instruction with the feedback, and the learner is going to spend approximately the same time with either choice, it may be appropriate based on other external objectives to include only second attempt in the practice question feedback.

Summary

This study examined the effects of two variables, level of feedback and number of attempts on the practice questions in a CAI lesson. The levels of feedback ranged from KOR, through KOR plus additional information, to the inclusion of a hint. Each level increased the level of informational feedback, and the hint also provided an alternate cue for the recall of the propositional networks. In addition, the information in the feedback focused on the correct attributes of the subject, a concept. The feedback did not focus on why the incorrect selection was wrong. Half of the students in each group also received a second attempt to answer the practice question. Student acquisition and retention was measured on an immediate posttest and a delayed posttest. The fact that feedback was initiated on student error necessitated the inclusion of a covariate, the percentage of errors on first attempt practice questions, in the computation of analysis of variance. The results supported the hypothesis that a second attempt to answer the practice question increased both acquisition and retention. The increased levels of

feedback, including hint, were supported as an aid for retention, but did not aid acquisition.

Instructional designers are able to easily add a second attempt after incorrectly answered practice questions to benefit acquisition and retention. While previously applied by instructional designers due to intuitive understanding of successful designs, the significant results of this study provide support for regularly incorporating second attempt into lessons. The addition of increased levels of informational feedback should be examined on a case-by-case basis, as adding complex feedback may significantly increase development costs. If retention is a consideration, extended informational feedback should be included based on the significant results of this study. The examination of the effect of the levels of informational feedback on concept acquisition should be confirmed with another research study, followed by examination of both independent variables from this study in rule learning and problem solving lessons.

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QUESTIONS AND FEEDBACK IN COMPUTER-ASSISTED INSTRUCTION

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This study investigated the effects that matching level of feedback with level of question has on academic achievement as measured by an immediate and delayed posttest. The level of feedback and level of questions were combined to form four treatment groups: low-level questions with KCR feedback, low-level questions with KCR+E feedback, high-level questions with KCR feedback, and high-level questions with KCR+E feedback.

Subjects were undergraduate students enrolled in a navigation course. There were no significant differences between groups on the immediate and delayed posttest scores when the level of feedback matched the level of question. However, subjects who received KCR feedback after low-level questions scored significantly higher on the immediate posttest than subjects who received KCR+E feedback after high-level questions. Additionally, subjects who received low-level questions scored significantly higher on the immediate and delayed posttests than subjects who received high-level questions.

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COOPERATIVE LEARNING IN COMPUTER ASSISTED INSTRUCTION

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A significant portion of instructional research has focused on individual instruction and success. However, the group approach may provide solutions to educational problems of efficiency, cost, limited resources and instructors. This study was to determine whether paired/cooperative computer assisted instruction (CAI)is as effective as an individualistic approach. This study also examined the interactive effects of individual cognitive style on paired/cooperative CAI. Three different pairings were analyzed according to affective and achievement measures. Of 86 students, 57 were randomly assigned to the paired/cooperative treatment and 29 were assigned to the individual instruction treatment.

No significant difference existed between the mean posttest scores of participants who worked individually and those who worked in pairs. The manner in which individuals are paired by cognitive style not only made a significant difference in achievement test scores but also in affective interaction. Groups containing at least one field independent student significantly outperformed groups containing two field dependent learners. Field dependent students, therefore, benefited significantly when paired with a field independent student.

Major Whyte graduated from the USAF Academy with a degree in International Affairs and American Politics. He is also a graduate of the University of Southern California, with a Master of Science degree in Education and a Doctor of Philosophy in Instructional Technology. After initial aircrew assignments as a Special Air Mission Instructor Pilot and as a Chief of International Programs, Pentagon, he was assigned to USAFA. In addition to his current responsibilities, he has taught five different university courses and served as a Squadron Training Officer.

COOPERATIVE LEARNING IN COMPUTER ASSISTED INSTRUCTION

INTRODUCTION

Many look to emerging technologies, such as computers, as our "new hope" for improvement in the quality of education. The amount of substantive research, however, involving how individuals or pairs learn on computers is relatively small. We know little about how learners with individual cognitive differences react to various teaching methods such as paired versus individual computer-assisted instruction (CAI). Educators need to learn more about the interaction of students and delivery systems in order to construct more effective models and tools. Researchers at the University of Southern California found that individuals with certain cognitive styles often react differently to paired learning situations. They also found that the pairing of certain individuals can have significant effects on both student attitude and achievement (Whyte, Knirk, Casey & Willard, 1990-91). This paper contains substantive information from not only the previously cited article but also from the author's dissertation research. Much more research is needed in the area of pairing students by individual differences.

COGNITIVE STYLE

In his article, Messick (1984) defines cognitive style as "characteristic self-consistencies in information processing that develop in congenial ways around underlying personality trends." He also states that cognitive styles are "intimately inter-woven" with motivational, affective and temperamental structures to produce total personality. Perhaps the most prolific writer in the area of cognitive styles was Herman A. Witkin. As part of his extensive research, Witkin, Moore, Goodenough and Cox (1977) determined that cognitive styles: 1) deal with the "form" of cognitive activity, not its content (e.g., thinking, perceiving, problem solving, etc.); 2) are "persuasive dimensions" in that they are a feature of not only personality but also cognition; 3) are stable over time; and 4) are also bipolar. In other words, being on one end of a cognitive style dimension may be useful in some circumstances while not in others. This aspect is in contrast to intelligence, for example, where "more" is always "better." Cognitive style is, therefore, concerned with how an individual processes information. This includes any process which acquires knowledge (e.g., memory, perception, thought, and/or problem solving). Cognitive styles are also not likely to change with training (Ausburn & Ausburn, 1978). Training, therefore, should be adapted to

the learner rather than the learner to training. Cognitive style is not a single entity. Most educational psychologists recognize nine to eleven major dimensions of cognitive style including: reflectivity/impulsivity; scanning; categorizing; and field independence/field dependence (Carrier & Jonassen, 1988).

OVERVIEW OF FIELD INDEPENDENCE/FIELD DEPENDENCE

According to Rasinski (1983), field independence/field dependence is "by far" the most researched of all cognitive styles. It also seems to have the greatest potential for application to educational problems. Most research in this area began in the early 1950's and 1960's. Herman A. Witkin, Donald R. Goodenough and Philip K. Oltman (1986) have produced most of the substantive research in this area in the last 30 years. According to Willard (1985), this dimension is concerned with a learner's ability to "perceive a part of a stimulus as discrete from its surroundings through active and analytic as opposed to passive and global processes". It is also significant to note that the FI/FD dimension is "bipolar". According to Witkin and Goodenough (1977), "each of the contrasting cognitive styles has components that are adaptive to particular situations, making the dimension value neutral".

Specific Characteristics of Field Independence (FI)

Canino and Cicchelli (1988) define FI individuals as those who are capable of perceiving items as discrete from background or field. They also learn better when they are allowed to develop their own strategies in problem-solving nonsocial domains. Rosenberg, Mintz & Clark (1977) compiled research findings on this particular dimension which dealt specifically with learning preferences and abilities. They found that FIs: 1) play a much more participant or active learning role; 2) learn more "efficiently" in conditions of self motivation; 3) learn more effectively without performance feedback; 4) do not seem to need an externally provided structure; 5) are more attentive to "nonsalient attributes in concept learning tasks"; and 6) tend to favor lectures (i.e., expository methods) (Rosenberg, Mintz & Clark, 1977).

Specific Characteristics of Field Dependence (FD)

These learners are defined as those who are not as able to separate "elements from their surroundings". They experience their environment more globally and usually accept the organization provided by the "perceptual field". FDs also prefer to interact with a teacher and tend to learn better with structure (Canino and Cicchelli, 1988).

Rosenberg, Mintz & Clark (1977) also compiled research findings on the FD dimension which dealt specifically with learning. They found that FDs: 1) tend to learn socially relevant material better than FIs; 2) usually perform a spectator or passive learning role; 3) are more affected than FIs by negative reinforcement; 4) tend to be more influenced by the opinions of others or authority figures; 5) possess lower "performance expectations"; 6) perform stereotyped roles; and 7) prefer discussions (i.e., interactive methods).

In other words, FIs and FDs are almost complete opposites in learning preferences and abilities. FI students are analytical and FD students are global.

PAIRED/COOPERATIVE VERSUS INDIVIDUAL INSTRUCTION

Numerous studies conducted since the mid-70's have also shown that cooperative teaching methods can be not only more effective but also more efficient than traditional methods (Johnson, Johnson & Stanne, 1986). Valient, Glachan and Emler (1982) cite Piaget's writings which place a significant importance on peer interaction. Piaget believed that social interaction not only provides learners with contrasting viewpoints and judgements, but also encourages them to support their own. Valiant's own research seems to support this as she found that cooperative learning was not only more effective but also more efficient in teaching

children classification skills (Valient, Glachan and Emler, 1982). Several other studies have also provided both interesting and significant conclusions in the area of paired/cooperative instruction. Noble (1967) conducted one of the first experiments which studied the attitudes of students who worked in pairs versus those who worked individually. He found no significant difference in attitudes between the two groups. Incidentally, he also found that a paired approach was a cost effective alternative for programmed instruction. In 1978 Cloutier and Goldschmid (1978) found a significant educational advantage of having peers interact during training. This seemed to be true even in the absence of an instructor. Merely pairing students, however, may not be the answer. We, as teachers, do not, as yet, know what makes-up an effective group.

Johnson, Maruyama, Johnson, and Nelson (1981) also found that paired/cooperative learning promotes higher achievement than either competivive or individualistic instruction. Much more research is needed in the area of pairing students by individual differences. The next part of this section will deal with the pairing of students by cognitive style.

Paired Learning and Cognitive Style

An example of a study which paired students according to ability or cognitive style was conducted by Amaria, Biran and Leith (1969). Results indicated that paired children significantly outperformed individuals. In this case, students were paired according to IQ. Homogeneous groups (i.e., those with similar IQs) outperformed heterogeneous groups (i.e.,those with a mix of above and below average intellectual abilities). Further findings also supported the fact that lower ability students were academically stimulated by bright students. These bright students were also kept from "jumping ahead." In another related study, Fitzgibbons, Goldberger and Eagle (1965) supported the notion that individuals with certain cognitive abilities can react differently to paired learning situations. They found that individuals designated as field dependent, for example, are more sensitive to "people centered" environments. As a result, they rely more on help provided by others. Coodenough also found that individuals with differing cognitive styles assume different roles when participating in paired instruction. He concluded that FDs are more socially oriented and perform a more spectator role during paired/cooperative training. FIs, on the other hand, perform a much more participatory role (Goodenough, 1976). In 1986 Bertini, Pizzamiglio, and Wapner supported this notion when they determined that FDs rely more on

interpersonal relationships and are more "socially oriented". They pay much closer attention to interpersonal cues, show more emotional openness in conversations and prefer to work physically closer to others. FDs also tend to particularly need other people's input when faced with ambiguous situations (e.g., novices in an introductory computer course). FIs, on the other hand, are not only vastly more impersonal, but also are disinterested in working with others either emotionally or physically. The way individuals are paired also seems to have an impact on the effectiveness of instruction. Oltman, Goodenough, Witkin, Freedman, and Friedman (1975) conducted one of the first studies which dealt with the pairing of individuals according to cognitive style. Results showed that dyads of "low-differentiation" (e.g., FI and FI or FD and FD) reconciled disagreements more often and displayed greater "interpersonal attraction" than dyads of "high-differentiation (e.g., FI and FD)".

COMPUTER ASSISTED INSTRUCTION (CAI)

CAI and Cognitive Style

Recent educational research has indicated that instruction can be made more effective if CAI is adapted to individual cognitive style (Cheney, 1980). Post (1987) also

found that FIs significantly outperform FDs in courses utilizing computer assisted instruction.

CAI and Paired/Cooperative Instruction

Studies show that the use of paired/cooperative teaching methods result in both more effective and more efficient computer assisted instruction (Hooper & Hannafin, 1988). Ronald S. Lemos (1979) has conducted an extensive amount of research in the area of cooperative computing. His research concluded that a team learning approach was significantly more cost effective in teaching COBAL programming. Developing cost effective alternatives for computer training is especially important since 70% of the U.S. labor force depends on data processing services (Lemos, 1978). There are also several purely pragmatic reasons for conducting a team approach in computer training. According to Khailany and Saxon (1978), individual computer processing is virtually non-existant in the commercial environment. Auld, Lang, and Lang (1981) warn against the "social isolation" of individual computer users. According to their research, these "isolates" have fewer opportunities to discuss their work and, therefore, may have unnecessary difficulty performing computing tasks. Her/his motivation and attitude toward computers is, as a result, negatively affected. The promotion of cooperative groups permits "egoless programming" as programs developed are the property

of the group rather than specific individuals (Lemos 1979 and Shneiderman 1980). These group processes, according to Shneiderman (1980), also serve as a type of group therapy as they encourage cooperation, endeavor to overcome anxiety and appear to build interdependence. Small groups encourage individual learners to "perform at higher levels" due to the fact that good work will be recognized.

PURPOSE OF THIS STUDY

The primary purpose of this study was to determine whether paired/cooperative computer assisted instruction (CAI) is as effective as an individualistic approach. This study also examined the interactive effects of individual cognitive style on paired/cooperative CAI. Three different pairings were analyzed according to affective and achievement measures (i.e., FI with FI, FD with FI, and FD with FD).

RESEARCH QUESTIONS

This investigation sought to answer the following questions:

1. What is the relationship between mode of instruction (i.e., paired/cooperative and individualistic) and achievement after computer assisted instruction?

2. What is the relationship between mode of instruction (i.e., paired/cooperative and individualistic) and attitude after computer assisted instruction?
3. How do various pairings of students, according to individual cognitive style, (i.e., FI and FD) effect student achievement?
4. How do various pairings of students, according to individual cognitive style, (i.e., FI and FD) effect student attitude?

METHODOLOGY

The research design selected for this study was a quasi-experimental, three-group, posttest-only design Each of the 86 participants of the training portion of this investigation was first administered the Group Embedded Figures Test (GEFT). The GEFT measures the cognitive style dimension of field independence and field dependence. The reliability of this test is .82 for both females and males [10]. After this preliminary test, students were randomly assigned to one of four groups. The groups consisted of the following: 1) individuals; 2) a FI paired with a FI; 3) a FD paired with a FI; and 4) a FD paired with a FD. The independent variable used in this experiment was the particular mode of instruction given to students. Out of 86

total students, 57 were randomly assigned to the paired/cooperative treatment and 29 students were assigned to the individualistic treatment. This method of group assignment is consistent with other studies of this type [8]. Students were then randomly assigned to computers. All students, regardless of instructional mode, however, received exactly the same instructional content. During the workshop students were taught a series of DOS commands by means of lecture and hands-on experience. Individual students were told to work on their own, while paired students were briefed to equally share "keyboard time."

Instruction included a self-paced computer tutorial which reviewed all of the basic DOS commands taught during the lecture portion. The tutorial, therefore, served not only as a review of the material, but also was an excellent control for our training. An additional twelve subjects made up the Control Group. The primary dependent variable utilized in this study was a participant's score on a 20 question test on various disc operating system commands. DOS commands included formatting, "booting", renaming files, and making and changing directories. Finally, students were asked to complete a questionnaire which was tailored to his/her randomly assigned mode of instruction.

A T-Test was used as a comparison of pairs' and singles' achievement tests. Analysis of the results of the three pairs of individual cognitive styles (i.e., FI with FI, FD with FI, and FD with FD) was accomplished by using a

one-way analysis of variance (ANOVA). Finally, the Scheffe Procedure was used to determine where the three pairs significantly differed at the 0.050 level.

DATA ANALYSIS

Table 1 shows that no significant difference existed between the mean posttest scores of participants who worked individually and those who worked in pairs.

TABLE 1

COMPARISON OF PAIR'S AND SINGLE'S ACHIEVEMENT TESTS

GROUP	NUMBER OF CASES	MEANS	STANDARD DEVIATIONS
PAIRS	57	14.2982	4.136
SINGLES	29	13.3793	4.981

<u>POOLED VARIANCE ESTIMATE</u>

T VALUE	DEGREES OF FREEDOM	2-TAIL PROB.
0.91	84	0.366

Both groups' means differed by less than one question. The pooled variance estimate revealed a T value of 0.91 and a 2-tail probability of 0.366.

After conducting the one-way analysis of variance (ANOVA) (see Table 2) it was obvious that a significant difference existed somewhere between the three groups. The means of the three groups differed significantly. Although the first groups' mean of 15.2632 was not significantly different from the second groups' mean of 15.7222, the third group, however, had a much lower mean than either of the two other groups of 12.1000.

TABLE 2

ONE-WAY ANALYSIS OF VARIANCE WITH MATCHED PAIRS

GROUP	NUMBER OF CASES	MEANS	STANDARD DEVIATIONS
FI W/ FI	19	15.2632	4.1075
FD W/ FI	18	15.7222	4.1559
FD W/ FD	20	12.1000	3.3230

	DF	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB
BETWEEN GROUPS	2	150.8345	75.4173	5.0459	.0098
WITHIN GROUPS	54	807.0953	14.9462		
TOTAL	56	957.9298			

A Scheffe Procedure was performed to support the results found from the one-way ANOVA. Table 3 shows that groups made up of either two FI students or a mixed group of

one FD and one FI student significantly out-performed groups made up of two FDs.

TABLE 3

SCHEFFE PROCEDURE

		GROUP	TYPE	
MEAN	GROUP TYPE	FI W/ FI	FD W/ FI	FD W/ FD
15.2632	FI W/ FI			*
15.7222	FD W/ FI			*
12.1000	FD W/ FD			

* Denotes Pairs of Groups Significantly Different at the 0.050 Level

Table 3 shows, therefore, that FDs benefit significantly when paired with a FI. FI students did equally well regardless of their partner.

According to the literature, FIs are analytical, independent, do not seem to need an externally provided structure and function with very little environmental support. FDs, on the other hand, show a lack of initiative and have a readiness to submit to authority (Witkin, Lewis, Hertzman, Machover, Bretnall Meissner & Wapner, 1954).

Table 4 shows that FD students paired with FI students or FD students paired with FD students enjoyed working in pairs more than FI students paired with FI students. This is, therefore, consistent with the literature as FI individuals not only are insensitive to social cues, but also function with very little emotional support. FDs, on the other hand, are more oriented towards people (Witkin, 1979).

TABLE 4

PAIRED STUDENT QUESTIONNAIRE RESPONSES
INCLUDES MEAN, SD, AND
PERCENTAGE OF REPONSES PER ITEM

To what extent did you enjoy working in pairs?

FIELD INDEPENDENT/FIELD INDEPENDENT

	1	2	3	4	5	
VERY LITTLE	11%	21%	47%	11%	11%	VERY MUCH

MEAN = 2.895 SD = 1.100

FIELD DEPENDENT/FIELD INDEPENDENT

	1	2	3	4	5	
VERY LITTLE	12%	12%	29%	24%	24%	VERY MUCH

MEAN = 3.353 SD = 1.320

FIELD DEPENDENT/FIELD DEPENDENT

	1	2	3	4	5	
VERY LITTLE	10%	15%	10%	15%	50%	VERY MUCH

MEAN = 3.800 SD = 1.473

FD students paired with FD students helped each other more during training than any other group (see Table 5). This is also consistent with the literature as FDs are more helpful than FIs (Witkin, 1979). The lower mean for FDs matched with FIs could be explained by the fact that FIs in this group were not interested in help, even if provided. Although FDs matched with FDs felt that they had been helped more during the lesson, their scores were the lowest of the three groups (see Table 2). It is possible that this group was merely socializing and not exchanging pertinent class information.

TABLE 5

PAIRED STUDENT QUESTIONNAIRE RESPONSES INCLUDES MEAN, SD, AND PERCENTAGE OF REPONSES PER ITEM

To what extent did your partner help you during the lesson?

FIELD INDEPENDENT/FIELD INDEPENDENT

	1	2	3	4	5	
VERY LITTLE	21%	16%	37%	16%	11%	VERY MUCH

MEAN = 2.895 SD = 1.100

FIELD DEPENDENT/FIELD INDEPENDENT

	1	2	3	4	5	
VERY LITTLE	18%	18%	35%	24%	6%	VERY MUCH

MEAN = 2.824 SD = 1.185

FIELD DEPENDENT/FIELD DEPENDENT

	1	2	3	4	5	
VERY LITTLE	10%	10%	30%	35%	15%	VERY MUCH

MEAN = 3.350 SD = 1.182

The next two tables support very similar areas in the literature. FIs not only learn more "efficiently" in conditions of self motivation, but also do not seem to need an externally provided structure (Rosenberg, Mintz & Clark, 1977). FIs also tend to keep to themselves or desire to

work alone (Witkin & Goodenough, 1981). Table 6 shows that almost half of the group of FIs matched with FIs desired to work alone. Table 7 shows that 90 percent of this group believes that they learn more by doing than by watching. These results are in contrast to other groups which contain FD participants. FDs prefer to work physically closer to others and usually perform a spectator or passive learning role (Witkin & Goodenough, 1977). Table 6 shows that fewer FDs, regardless of group, prefer to work alone. Results of Table 7 show that more FDs, in general, believe they learn more by watching than their FI counterparts.

TABLE 6

PAIRED STUDENT QUESTIONNAIRE RESPONSES INCLUDES MEAN, SD, AND PERCENTAGE OF REPONSES PER ITEM

I prefer to work ________.

FIELD INDEPENDENT/FIELD INDEPENDENT

LARGE GROUP 1	SMALL GROUP 2	ALONE 3
0%	53%	47%

MEAN = 2.474 SD = .513

FIELD DEPENDENT/FIELD INDEPENDENT

LARGE GROUP 1	SMALL GROUP 2	ALONE 3
0%	71%	29%

MEAN = 2.294 SD = .470

FIELD DEPENDENT/FIELD DEPENDENT

LARGE GROUP 1	SMALL GROUP 2	ALONE 3
5%	63%	32%

MEAN = 2.263 SD = .562

TABLE 7

PAIRED STUDENT QUESTIONNAIRE RESPONSES INCLUDES MEAN, SD, AND PERCENTAGE OF REPONSES PER ITEM

I learn more by ________.

FIELD INDEPENDENT/FIELD INDEPENDENT

WATCHING	DOING
1	2
10%	90%

MEAN = 1.895 SD = .315

FIELD DEPENDENT/FIELD INDEPENDENT

WATCHING	DOING
1	2
18%	82%

MEAN = 1.882 SD = .485

FIELD DEPENDENT/FIELD DEPENDENT

WATCHING	DOING
1	2
21%	79%

MEAN = 1.789 SD = .419

DISCUSSION

This study attempted to determine whether paired/cooperative computer-assisted instruction (CAI) is as effective as an individualistic approach. The study also examined the interactive effects of individual cognitive style on paired/cooperative CAI. Results showed that no significant difference existed between the mean posttest scores of participants who worked individually and those who worked in pairs. The manner in which individuals are paired by individual cognitive style also made a significant difference in individual achievement test scores.

Groups made up of either two field independent students or a mixed group of one field dependent and one field independent student significantly outperformed groups made up of two field dependents. Although field dependents matched with field dependents enjoyed working in pairs more than any other group, the optimal pairing included one field independent student. Field independent students performed equally well regardless of their partner and field dependent students benefited significantly when paired with a field independent student. Training performed in this manner was, therefore, found to be not only more efficient, but also more effective.

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RESEARCH

USING AUDITORY REINFORCEMENT IN COMPUTER-BASED INSTRUCTION

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ABSTRACT

Interactive computer-based instructional (CBI) systems suffer a serious deficiency: limited interactivity. Research suggests that the level of interactivity is an important factor in the effectiveness of CBI. The technology to make CBI delivery more conversational now exists. Given the possibilities of more conversational CBI delivery, there is a need to establish principles to guide the use of this technology. The Air Force Human Resources Laboratory is conducting a series of experiments at the School of Aerospace Medicine to establish prescriptions for the use of auditory presentations in CBI. This paper reviews the research findings to date in the area of auditory presentations in CBI. In addition, we present the design of our initial experiment which is intended to test the hypothesis that auditory reinforcement could extend the normal memory limitations that pertain to procedural knowledge.

INTRODUCTION

Recent advances in computer technology make it possible to incorporate speech generation and recognition into the construction of human-computer interfaces (HCIs). Research in cognitive and experimental psychology indicates that presentation modality has an effect on recall and retention (cf., Gathercole and Conway, 1988, and Penny, 1989). Studies of computer-based instruction (CBI) tend to indicate that the level of interactivity influences the effectiveness of the instruction (Jonassen, 1985). Given the current trend toward more CBI and the desire to make CBI more effective, it is natural to expect that auditory presentations will become more common as CBI becomes more conversational and more interactive. As a result, there is a need to develop principles for the optimal use of auditory presentations in CBI.

This paper reviews what is known about computer-based auditory presentations. The research literature in human factors design, experimental and cognitive psychology, and educational technology is

reviewed as a precursor to establishing prescriptions for auditory reinforcement in CBI. In addition, a method to empirically test and refine prescriptions and principles pertaining to auditory presentations is discussed. The first experiment in an experimental suite aimed at establishing guidelines for the use of auditory presentations is also presented.

REVIEW OF RELEVANT RESEARCH

A growing body of literature in human factors, computer technology, and cognitive psychology has called for the implementation of a more versatile and meaningful HCI (Cooper, 1987). The trend is toward a natural communication link between user and computer. The result will be more conversational computer systems. The potential benefit to CBI is that the level of interactivity can be more varied and, therefore, more effective.

Although speech is arguably the most natural form of interpersonal communication, it is also the least developed form of human-computer communication. One reason for this, of course, is that reasonable digitization and compression algorithms are relatively new and that only recently has cost ceased to be a major factor in adding speech generation and recognition to a personal computer. The experiment discussed below makes use of a COVOX speech generation system. The COVOX system is also capable of voice recognition (all for less than $200), but this aspect of HCI was not explored in this experiment due to the inherent complexities of voice recognition.

In spite of the widespread use of auditory presentations in learning situations from preschool to the post-graduate level, the psychological, educational, and human-factors literatures do not contain much research concerning how humans acquire knowledge and make inferences based on aurally presented information. Not much is known about how individuals integrate aural feedback with nonredundant information and what skill determinants in this area exist.

The guidelines which do exist pertaining to auditory presentations are mostly intuitive or commonsensical and pertain primarily to non-speech audio cues. The table below depicts a typical example of a decision procedure for determining whether to use an audio or visual channel for the presentation of information (Deathridge, 1972):

<u>Use auditory display if:</u>

The message is simple.

The message is short.

The message will not not be referred to later.

The message deals with events in time.

The message calls for immediate action.

The visual channel is already overloaded.

The receiving location is not well lit.

The person's task requires continual movement.

Use visual display if:

The message is complex.

The message is long.

The message will be referred to later.

The message deals with events in space.

The message does not call for immediate action.

The audio channel is already overloaded.

The receiving location is noisy.

The person's task does not require motion.

Many of the principles suggested in this adaptation of Deathridge's decision procedure have not been empirically justified. Indeed, findings in cognitive science suggest that some may be incorrect. For example, events in time can be given a spatial representation. The essential consideration is determining whether a spatial representation of events contributes to a meaningful mental model appropriate to the learning task at hand.

More recent research reflects the same emphasis on non-speech auditory displays and the same lack of rigorous empirical justification. For example, Sanders & McCormick (1987) propose that auditory displays are preferable to visual displays when one or more of the following apply:

1. The origin of the signal is itself a sound.

2. When continuously changing information of some type is presented (see also Gaver, 1989).

3. When speech channels are fully employed.

4. When a verbal response is required.

There is scant research about how best to convey different substantive categories of information using alternative auditory displays. For example, to convey information about a database, a new use for auditory displays, one must convey information about appearances, states, structures, functions, processes, etc. (Sumikawa, 1985; Bly, 1985; Gaver, 1989). To do this successfully requires a principled means of choosing one or another method of presentation as being best suited to a particular application.

The literature reviewed suffers several limitations. First, the main emphasis in

the psychological literature concerns how auditory information is perceived and remembered. There is little psychological research on how displays can be used to best represent particular information about a particular subject domain for a particular instructional purpose to a particular kind of student.

A second limitation in the psychological literature is that there has been significant emphasis on the differences between novices and experts, but relatively little emphasis on how expertise is acquired. As a consequence, the educational implications of much of the psychological research are quite limited.

However, the psychological literature does suggest that multiple sensory sources have a generally positive effect on memory (Wickens, 1984). In Wickens' model, separate resource pools are hypothesized to exist for different types of stimulus codes and for different stages of processing. The implication for instructional technology is the suggestion of these auditory principles:

1. Learning is facilitated when stimuli are input to different channels.

2. Learning is facilitated when stimuli are of qualitatively different types, resulting in multiple encoding of input stimuli.

The costs and benefits of multiple resources (presentation modalities) and redundancy is a primary focus of the research described below.

In general, however, the research emphasis has typically been on aural versus visual or textual presentation. Relatively little consideration has been given to comparative evaluations of auditory presentations in various instructional modalities (e.g., feedback, explanation, etc.).

The human factors literature emphasizes the principal ergonomic implications of using particular delivery media and channels. The available literature deals with signal intensity, signal-to-noise ratios, discriminabililty, and the like (Smith & Goodwin, 1970). The following existing principles of human factors engineering will probably prove to be extensible to the auditory domain:

1. Selection of signal dimensions and encoding should align with learned or natural relationships of the user (e.g., using high frequencies to signify an increasing value).

2. When presenting complex information a two stage signal should be used (e.g., use one signal to attract attention and a second signal to designate particular information).

3. Stimuli should be

discernible from the environment.

Other similar principles can be extracted from the human factors literature. As with the psychology and educational literatures, there is not a lot of specific research pertaining to the use of auditory presentations in CBI. In addition, many human factors principles are simply intuitive and not empirically justified. Much research remains to be accomplished before we fully understand the limits of the human auditory channel. The details of auditory chunking, auditory overload, auditory transfer, and the other auditory considerations which have implications for learning and the design of instruction remain to be discovered.

INITIAL EXPERIMENTAL DESIGN

The Human Resources Directorate (AL/HRTC) and the School of Aerospace Medicine (SAM) have established a Memorandum of Understanding to allow collaboration on projects of mutual interest or benefit. AL/HRTC will conduct a series of experiments at the computer learning facility at SAM to establish auditory prescriptions to guide the optimization of auditory presentations in CBI.

The initial experiment is designed to test the hypothesis that auditory reinforcement can improve recall and retention of procedural knowledge. A COVOX speech system in a Z-248 microcomputer provides the speech capabilities. A lesson module authored in TenCore provides the CBI setting. Calls to the speech system are made via the TenCore EXEC command. Digitized recordings of actual human speech will be used, as research indicates this is more likely to be effective than synthesized speech (Pisoni, 1982).

The lesson module involves the completion of a medical form used to record the results of several types of medical examinations. This material is part of the Aeromedical Technician Course taught at SAM. The learning tasks are primarily procedural in nature. The lesson module will contain approximately 45 minutes of student CBI.

Experimental subjects will be familiarized with the elements of the CBI system, including the keyboard, the screen, and the speech system, prior to the initiation of the experiment. During this familiarization phase, subjects will be queried or presented information using auditory, graphical, and textual presentations.

The main body of the lesson module will be presented using alternating blocks of nontestable and testable material. This approach allows student motivation to be determined at various points in the instructional sequence (Lepper & Malone, 1985).

Six instructional treatments will be examined: 1) auditory, 2) textual, 3) combined auditory and textual, 4) combined auditory and graphical, 5) combined graphical and textual, and 6) combined auditory, textual, and graphical. The point of selecting these presentation combinations is to explore the multiple resource hypotheses elaborated earlier.

MEASUREMENT AND ASSESSMENT

Delayed retention will be measured in terms of recall. Subjects will be administered constructed response items to determine the extent of their retention. Recognition is not measured in this study, because the medical form cannot be legitimately used by someone who is only capable of recognizing the correct procedures and lacks the ability to perform those procedures.

Measurement and testing conditions of this study will resemble as closely as possible those currently in use in the existing Aeromedical Technician course. Therefore the criterion for delayed recall will require that the subject demonstrate the correct procedure for completing a particular item on the medical form. All subjects will be tested after a delay of one day, as is the case in the existing Aeromedial Technician course. An added benefit of keeping the measurement and testing conditions as close currently in use is that comparisons with existing databases can be made to determine the general efficacy of the CBI course module relative to the classroom-based module.

As an additional measure of the impact of the different instructional presentation methods in the absence of any opportunities for rehearsal, some of the ostensibly "non-testable" material will be tested. Thus, it will be possible to assess the effects of the instructional presentations without the likelihood of inflated performance due to rehearsal during the instruction.

CONCLUSION

The implementation of auditory presentations should be systematically planned and designed with the entire instructional system in mind. Matching media, types of instructional objectives, types of subject matter, and learning characteristics is not a simple task. Guidelines for the design of interactive courseware should include prescriptions for the use of auditory displays that maximize the efficiency of the auditory channel for particular types of material and learning objectives.

The Advanced Instructional Design Advisor (AIDA) project at AFHRL is an attempt to provide courseware authoring guidelines to courseware developers (Muraida & Spector, 1990). Clearly, AIDA will need the capability to prescribe when auditory presenta-

tions are preferable to textual or graphical presentations, to suggest what sorts of auditory presentations are most likely to be effective for a particular purpose, and to indicate what auditory conventions should be observed.

As learning technology evolves, there will be an increasing role for the use of advanced technologies such as speech recognition and artificial neural networks in interactive courseware (Spector, 1990). In short, the demand for principles and guidelines for the effective use of auditory presentations in CBI will continue to grow. As a consequence, conducting experiments to establish these principles will play a vital role in the success of future learning systems.

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COMPUTER-BASED VOICE RECOGNITION TECHNOLOGY IN FUNCTIONAL FOREIGN LANGUAGE TRAINING

Abstract

The Futures Training Division of the U.S. Army Training and Doctrine Command is demonstrating the application of a new technology that eliminates any self certification of language pronunciation on the part of the foreign language student. The computer technology incorporates speaker independent speech recognition that evaluates discrete speech (words or phrases spoken within 4 seconds) on accuracy of pronunciation and enunciation.

This automated system is used to replace the tape player used for audio recording and playback. It provides a drill and practice capability that is interactive, and thus, the student becomes completely involved in all aspects of learning to speak that language. The system teaches the basic skills --vocabulary, pronunciation, and syntax-- required to learn a foreign language. Once the student has acquired this skill, conversational experience may be obtained in either a classroom or a natural environment.

Computer based instruction drill and practice lessons, utilizing voice recognition technology, have been developed in Spanish and French for functional language training of the Army's Special Forces units. In an on-going study, the lessons are being evaluated to determine their training and cost effectiveness as compared to traditional language lessons.

Author Biographies

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COMPUTER BASED VOICE RECOGNITION TECHNOLOGY IN FUNCTIONAL FOREIGN LANGUAGE TRAINING

Marta J. Bailey and
Gary G. Wright

Instructional methodology in the area of foreign language training is a widely discussed topic among educators. There are groups of educators who prefer a complete immersion of the student in the target language and a group of educators who prefer the more traditional method of teaching strictly defined grammar rules that emphasize the written capabilities of the new speaker. One method is unlikely to be agreed upon by all educators.

A common element of both methods is the time the student must devote to practicing pronunciation and learning new vocabularies. The most traditional method involves spending time in a language laboratory wearing a headset in order to listen to a native speaker and practicing speaking the language by recording your voice and listening to the playback. This activity is generally a most boring task and it is extremely difficult to apply one's total concentration. Certification of when and how well you are speaking the target language is strictly a judgement call made by the speaker. Self certification may be accomplished in a relatively short amount of time.

This paper will describe the application of a new technology that eliminates any self certification of language pronunciation on the part of the student. The computer technology incorporates speaker independent speech recognition that evaluates discrete speech (words or phrases spoken within 4 seconds) on accuracy of pronunciation and enunciation. This automated system replaces tape players used for audio recording and playback. It provides a drill and practice capability that is interactive and thus the student becomes completely involved in all aspects of learning to speak the language. The system teaches the basic skill--vocabulary and pronunciation--required to learn a foreign language. Once the student has acquired this skill, conversational experience may be obtained in either a classroom or a natural environment.

This project is a part of the Army's concept of distributed training whereby a substantial percentage of training will be delivered outside of the traditional school house setting. The Futures Training Division of the Army Training and Doctrine Command (TRADOC) is sponsoring a pilot research project in conjunction with EER Systems and the John F. Kennedy Special Warfare Fighting Center and School at Ft. Bragg, North Carolina.

At this school, sixteen different languages are taught to military special forces units who must communicate with both friendly and enemy forces once they have landed on foreign soil. The methodology involves teaching the language in a structured functional approach. There are ten basic lessons that deal with the structure of the language and a generic set of words (numbers, salutations, etc.). An additional 38 lessons involve functional areas such as medical tasks, demolition, communications and so on. These tasks require a vocabulary of approximately 2500 words and/or phrases.

The hardware components of the language training system are an IBM compatible personal computer such as a Zenith 248, EIDS, or laptop and an off-the-shelf signal processing board. To complete the delivery system, speech recognition software and mission oriented training scenarios are developed. The most significant feature of this language training system is that it provides an interactive capability for the student to:

- Hear a word or phrase pronounced properly by a native speaker, and

- Say the word or phrase back to the system, and

- Receive Immediate Feedback from the system that will tell the student if the word or phrase was pronounced correctly or incorrectly, and

- Repeat the words and phrases again and again until the pronunciation is correct.

The system is very close to having your own personal instructor, because essentially you talk to the system and it talks back.

The most important aspect of the speech recognizer is its ability to recognize any person's speech regardless of accent, tone, or variations in speech characteristics associated with the sex of the speaker.

The primary objective is for the speaker to pronounce the word/phrase as it has been pretrained by native language speakers. Most recognizers in today's market try to accommodate for any speaker; this system requires the speaker to accommodate to the correct pronunciation. If a misrecognition or nonrecognition occurs, it is a measure of poor performance (pronunciation) and not an error in the recognition system.

Another important feature is the capability to train a specific language dialect. For example, if the mission requirement necessitates proficiency in Colombian Spanish, the system can be "trained" to "speak and understand" Colombian Spanish. If the requirement is to have a broad-based Spanish capability, then the system would be trained across a variety of Spanish speakers.

The system can train vocabulary and phrases up to four seconds in length. A four second phrase on average, translates into six to eight words, which includes the majority of military requirements.

The system is easily transportable which makes standardized sustainment training at home station a reality.

The application is designed to teach individual words; providing the speaker the opportunity to listen to each word as modeled by a native speaker. After all words have been pronounced correctly, the words are grouped into phrases until a functional sentence has been spoken. If the sentence is more than 4 seconds in length, the system will not recognize, but will digitize the speaker's voice and provide playback so that the speaker may listen to his/her pronunciation.

The present method of teaching foreign language at the school involves an intensive 8-10 hour day for each student. Soldiers spend approximately six hours in class practicing speaking. Each evening, they are required to learn a new vocabulary of about 50 words. They practice speaking the new vocabulary and then complete some paper based exercises. They use cassette tape players to learn the new vocabulary, to model the pronunciation, and to receive instructions to complete the exercises. The following day, they generally spend the first hour or two in class in learning the vocabulary as a group which suggests that homework practice time has not been as effective as desired. Time spent reviewing homework reduces the conversational practice to approximately four hours.

The use of the automated system is expected to reduce the student's learning time. If they know their vocabulary, they could use the first 4 hours of the day to practice conversational exposure, then they could use the afternoon (in a laboratory environment) to learn and practice the new vocabulary for the next day and complete more meaningful exercises administered by the computer.

The systems computer management function will also provide a documented audit trail of the use the system to see how much time is needed to learn new vocabularies. This information could be valuable in future development.

TRADOC provided 12 computers with voice recognition capability for a learning lab setting at the JFK Special Warfare Fighting Center and School. Ideally, all students should receive a personal computer for home use during the duration of language training. Spanish and French drill and practice lessons will be formally evaluated for training and cost effectiveness.

The potential value of this approach to language training lies primarily in unit based sustainment training. Language training deteriorates rapidly without use and practice. Both the active and reserve Army forces have strong needs for affordable, convenient sustainment training.

The hardware costs for this system are nominal. A $1500.00 signal processing board is added to a standard AT compatible microprocessor. Research and development costs of less than one million dollars have brought the programmers to the point of being capable of rapidly developing additional languages.

THE DEVELOPMENT OF ALTERNATIVE STRATEGIES

John E. Buckley

Abstract

Our current training system relies on three training strategies, one for officers, one for warrant officers, and one for enlisted personnel. Training is descriptive in nature. All soldiers receive the same training or type of training without regard to the skills and knowledges of the individual or the complexity of the training. In an era of declining budgets, this may not be the most cost-effective method of organizing the training system.

As a case in point, fifty percent of the Army are in their first term of service. During this period, they attend Basic Training and Initial Entry Training. This accounts for approximately fifty percent of our training dollars. The return on these training dollars is questionable, since only thirty-three percent will reenlist for a second tour. Training options must address either increasing the number of reenlistments or shifting the training emphasis to focus on those who plan to make the Army a career not a short term job.

To assist in the analysis and development of alternative strategies, a two dimensional model was constructed. It is predicted on the assumption that different clusters of occupations share certain characteristics which can be used to custom tailor training strategies.

Author Biography

MR. JOHN E. BUCKLEY

Mr. John E. Buckley is a Futures Education and Training Analyst assigned to the Training and Doctrine Command, Deputy Chief of Staff for Training, Fort Monroe, Virginia. He is responsible for analyzing future trends, current training, Army systems and technologies, to develop future training concepts. Prior to this assignment, he served in various training development capacities at the Air Defense School to include; Chief of the Individual Training Division and Deputy Division Chief, Professional Development Division. While serving in this capacity he received the Commander's Medal for Distinguished Civilian Service as Fort Bliss Supervisor of the Year. As a Project Manager he was directly responsible for fielding several self-paced courses on the Forward Area Alerting Radar, Hawk Launcher, Hawk Radars, and Chaparral Weapon Systems. In a follow-on assignment he performed the analysis, design, and development efforts which culminated in the Army's first First Sergeants' Course. As Chief of the Learning Center Branch, he was responsible for the establishment of the Air Defense School's first learning center. While in the service he taught radar maintenance for the U.S. Army Signal School, and received several citations for instructor excellence. He has a Bachelors of Science Degree in Education from New Mexico State, Las Cruces, and a Masters Degree of Education from Sul Ross University, Alpine, Texas.

ALTERNATIVE STRATEGIES

John E. Buckley

The Armies' current training system relies on three training strategies-- one for officers, one for warrant officers, and one for enlisted personnel. Training is descriptive in nature. All soldiers receive the same training or type of training based on a program of instruction structured to a traditional service school environment. This is without regard to the skills and knowledges of the individual or the complexity or nature of the training required.

The Enlisted Personnel Management System has classified 33 Career Management Fields (CMF). Each is further broken down into clusters of Military Occupational Specialties (MOS) which total 332. These range in training complexity from simple (i.e., Motor Transport Operator) to complex (i.e. Patriot Operator & Systems Mechanics). Training duration in the service schools varies, accordingly, from a minimum of 13 weeks to a maximum of 46 weeks training. There is also a wide divergence in the physical and psychological demands associated with each MOS. Some are primarily psychomotor, others are highly cognitive. Some are highly technical, others highly tactical. In looking at the total spectrum of enlisted training, it became readily apparent that the "one size fits all" training approach may not be the most cost-effective. The situation is further exacerbated by a high turn-over rate in many MOS.

As a case in point, fifty percent of the soldiers are in their first term of service. During this period, they attend Basic Training and Initial Entry Training which accounts for approximately fifty percent of the Armies' training dollars. The return on these training dollars is questionable since Armywide reenlistment rates average only thirty three percent. To bring the dilemma into sharper focus, in 1988 the Army trained 5022 Light Wheeled Vehicle Mechanics. Of these, only 788 reenlisted as Light Wheeled Vehicle Mechanics and 1542 reenlisted for other MOS which created an additional retraining requirement. The remaining 2692 personnel left the service after their first enlistment. An analysis of 20 other MOS showed similar patterns. In order to provide a greater return on initial entry training dollars, alternative strategies should be explored. The challenge was to develop a methodology for clustering MOS so that these alternative strategies could be focused on occupations sharing similar training characteristics.

To assist in the analysis and development of these alternative strategies a two dimensional model was constructed (See Figure 1). It is predicated on the assumption that different CMF have different training complexities which warrant different strategies, and that individual differences in soldiers may warrant different approaches. It also assumes that the Army may not be able to sustain its current training base in the future. As such, it must look externally to meet some of its future training requirements.

See Figure 1.

The X-Axis denotes the training complexity of the Career Management Field. The Y-Axis denotes how uniquely military the training may or may not be. The more green, the more unique the training is to the Army environment.

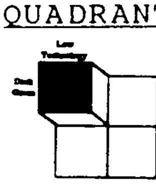
As shown, career management fields can be coarsely grouped together based on their greenness or their uniqueness to the Army, and whether the technological training requirements are high or low. Four classifications of CMFs result from this clustering. A further analysis indicates that the resulting clusters share certain characteristics which may warrant different training strategies.

In classifying CMF's in this manner, it is important to note that a sophisticated highly technical weapon system, like the Stinger, may in fact have a low technological training requirement. (Some experts have amplified either real or perceived man-machine interface problems with this system. Although approximately seventeen steps are required to fire a Stinger, they are relatively simple sequential steps best learned through drill and practice.)

Although it has been useful to look at enlisted training at a macro-CMF level, it became readily apparent as exceptions surfaced, that in order to fine tune the strategies, individual MOS would have to be examined. For example as shown in Figure 2, while CMF 16 generally shares the characteristics associated with dark green, low-tech MOS, the CMF does contain an MOS which can be classified in a different quadrant.

See Figure 2.
CMF-16 Air Defense Artillery

<u>DARK GREEN, LOW TECH QUADRANT</u>



These Career Management Fields contain MOS which involve the operation and maintenance of military peculiar equipment or systems. As such, there

are no existing civilian institutions which train these occupations. Many of the Combat Arms MOS fall into this quadrant.
One of the systemic problems in the service schools is a lack of tactical equipment for training. In order to utilize scarce tactical equipment to its greatest advantage, functional context training in the unit may have merit. All soldiers would receive an abbreviated common/
generic AIT in conjunction with basic training after which they would report to a unit for supervised on-the-job training (SOJT) enhanced by Distributed Training. This strategy gets the soldier to the unit sooner and saves a Permanent Change of Station (PCS) move which results in substantial savings.

Since these are the most inexpensive MOS to train, (from an individual soldiers perspective) a revamping of our recruitment efforts may be warranted. Personnel could be recruited into dark green, low tech CMF's and be offered more sophisticated, costly training as an incentive to reenlist. Implementation of such a policy would provide more return on the training investment by providing more expensive training to the thirty three percent of the population who demonstrate an interest in remaining in the service by reenlisting. (Further advance training could be provided to the seventeen percent of this population who reenlist for a third tour.)

In summary, the dark green, low technology MOS share the following:

CHARACTERISTICS:

1. Contains MOS which are not readily found being trained by the civilian sector or industry.

2. Are of relatively short duration.

3. Have low technological training demands.

4. Representative MOS:

a. 11B Infantryman

b. 16S Manportable and Pedestal Mounted Stinger Crewmember

c. 12B Combat Engineer

5. Have relatively low Army Services Vocational Aptitude Battery Requirements.

6. More Psychomotor than Cognitive.

7. More tactical than technical.

8. High Density.

9. Require ranges/ simulations for optimum training.

STRATEGIES:

1. Focus recruitment efforts on first enlistment.

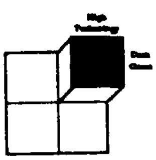
2. Best trained in a unit environment.

3. Permanent Change of Station to Unit after a "generic Advanced Individual Training."

4. Train in COHORT context.

5. PCS to Unit for SOJT.

DARK GREEN, HIGH TECH QUADRANT



This quadrant, like the previous one, is characterized by military peculiar hardware or systems. Most of the CMFs involve the maintenance of highly complex weapons systems requiring a high degree of knowledge of electrical and hydraulic system operation and repair. Some examples include the Hawk and Patriot Weapon systems. Training duration exceeds 30 weeks for most of the MOS.

From a population density perspective, it appears feasible that an MOS migration path could be created to transition second term enlistments from the Low Tech, Dark Green CMFs. Personnel who served as operators for 2-3 years on the systems would have already acquired such substantial backgrounds in such areas as operator preventative maintenance, system geometry, nomenclature, normal and abnormal system operational characteristics. They would, therefore, require substantially less training then current maintenance personnel are receiving. Opportunities through the tuition assistance program could provide electronics training via community colleges to operators who express a desire to reenlist into the high tech, dark green CMFs. If this training occurred prior to the second enlistment, it would reduce training in the electronic dark green, high tech MOS, by approximately 10 weeks. This, coupled with first enlistment skills and knowledges training, has the potential of reducing training for these long MOS by thirty to forty percent. In summary, CMFs in this quadrant share the following:

CHARACTERISTICS:

1. Contain MOS which are not readily found trained by civilian sector or industry.

2. Are of relatively long duration.

3. May have enabling skills and knowledges found in civilian sector.

4. Have high technological training demands.

5. Tend to be most costly (Per soldier).

6. More Cognitive than Psychomotor.

7. Representative MOS:

a. 24T Patriot Operator Maintainer

b. 27K Hawk Firing Section Repairer

c. 33Q E/W Intercept Strategic Processing/ Storage Equipment Repairer

STRATEGIES:

1. Offer as an incentive for second reenlistment.

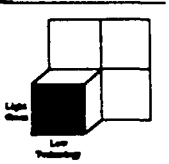
2. Best trained in service school environment.

3. May include "front loaded" enabling skills and knowledge training.

4. Develop career migration patterns to transition from other similar "Low Tech" MOS held during the first enlistment.

5. "Grow" Maintenance Personnel from Operator "Low Tech, Dark Green CMFs.

LIGHT GREEN, LOW TECH QUADRANT



The tasks associated with the MOS in this quadrant are readily found in the civilian sector. Generally, these are the "blue collar" military occupational specialties. Strategies which focus on recruitment by audition or achievement will help reduce front-end training costs. This will require the adoption of novel more aggressive recruitment practices. For example, the Army's total requirements for band members could be met by proactive recruitment. If recruiters visited the various High School Bands in the nation and toured with the All American High School Band, they could offer a career in music to high school seniors. In this particular field, the Army would have little competition and could offer an advanced promotion if the enlistees could pass a certification test. Since we are recruiting personnel who already possess the skills we need, there would be no need to send them to AIT. They could proceed to a Unit immediately after BCT. Ultimately, this would lead to a closing of the Music School at a substantial savings. While this example is probably the most dramatic, the same strategy could be applied to the other low tech, light green MOS, especially in those areas commonly taught in high school vocational education programs.

CHARACTERISTICS:

1. Subjects being taught in civilian sector.

2. Are of relatively short duration.

3. Have low technological training demands.

4. Involve simple hardware or tasks found in civilian sector.

5. Relative low cost to train per student.

6. Representative MOS:

a. 88M Motor Transport Operator

b. 71L Administrative Specialist

c. 63B Light Wheeled Vehicle Mechanic

7. More psychomotor than cognitive.

STRATEGIES:

1. Incorporate civilian off-shelf courseware.

2. Utilize community colleges, high schools, or industry to train.

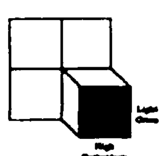
-- Train in high school Military Science Vocational Program.

-- Attend community college either after or prior to BCT.

3. Recruit by achievement or audition verses ability.

4. Contract for training or for services provided.

LIGHT GREEN, HIGH TECH QUADRANT



The CMF's in this quadrant are generally considered paraprofessional or professional occupations by the civilian sector. They generally have lengthy formal educational requirements such as associate or bachelors degree educational programs. This provides the concentration of cognitive skills in areas such as mathematics, science, and english required by many of the CMFs in this quadrant. Many of the occupations also have licensing requirements and national standards as in the case health services CMFs. All require sophisticated cognitive skills and an ability to perform abstract reasoning.

CHARACTERISTICS:

1. Subjects taught by civilian sector.

2. Are of relatively long duration.

3. Have high technological demands.

4. Involve sophisticated hardware or require high technical knowledge.

5. Relative high cost to train.

6. Representative MOS:

a. 91C Practical Nurse

b. 93H Air Traffic Control Radar Controller

c. 35K Avionics Mechanic

STRATEGIES:

1. Recruit by achievement verses ability.

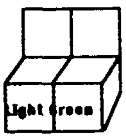
2. Create incentives for recruitment of community college graduate.

3. Mold/influence technical training in high school, community colleges, and industry.

4. Utilize total national training resources.

5. Offer as incentives for second term enlistment.

LIGHT GREEN MOS



One basic premises underlying the identification of the "light green" MOS is that in this era of declining resources, the Army must capitalize on the total training/educational assets of the nation to meet some of its training needs. These assets include public educational and training facilities and commercially available off-the-shelf courseware which can be used to train the 179 "light green" MOS. Even a cursory analysis shows training is occurring in the public sector that mirrors military service schools. The problem is to either identify or create an infrastructure to capitalize on these resources. There are several approaches which are under investigation:

1. Utilize existing on-going programs.

ADVANTAGES:

a. Probably cheapest approach.

b. Can Evaluate before utilization (try before we buy).

c. Possibly better training.

DISADVANTAGES:

a. Danger of either overtraining or under-training.

b. Training may be inconsistent.

c. Training may occur in small increments over extended periods.

2. Have schools custom tailor instruction to meet specific training needs.

ADVANTAGES:

a. Eliminates Over or Under training.

b. Can ensure consistent training.

c. Most time sensitive.

DISADVANTAGES:

a. More costly.

b. Reduced training sites.

3. Use Off-Shelf Commercial Programs to Train.

ADVANTAGES:

a. Most cost-effective.

b. Unlimited Training sites.

c. Most time sensitive.

d. Most consistent.

DISADVANTAGES:

a. Unable to custom-tailor to specific needs.

b. Not total MOS, only Modules.

4. Distribute VOTEC Training from the Public Sector.

ADVANTAGES:

a. Unlimited Training sites.

b. Can be time sensitive.

c. Consistent Training.

DISADVANTAGES:

a. Costs may be prohibitive.

b. Distribution System may not be in place.

Each of the alternatives could be adapted to various models which depict when, where, and how training will be delivered within administrative and legislative constraints. A feasibility study on the use of various VOTEC models is currently being performed. Phase 1 of this effort will determine which models can be implemented and the methodology for doing so. Phase 2 will conduct pilot programs using the approved models. The four models include:

1. High School Model
2. Preaccession Model
3. Industry Model
4. Post Accession Model

See Figure 3.

High School Model One of the more novel concepts is for the Army to mold the vocational training programs in the high schools to help meet our training needs. This concept would be most feasible for light green, low tech military occupational specialties. Related VOTEC programs already exist in many of the nations high schools. In others, a military science vocational technical curriculum could be introduced in the high schools. This would be an extension of the Junior ROTC program. While this programs' focus is on building citizenship, Army Regulations authorize the development of such a vocational track.

Under this proposed scenario, military science would be offered as an alternative to traditional VOTEC training in Junior and Senior years of high school. It is envisioned that a junior in high school would be presented various Military Vocational Options from the local recruiter. A student would receive skill level one training along with the normal mandatory high school subjects. The Military Science VOTEC could also address generic hard skills associated with the operation and maintenance of military systems. Under provisions of the Technology Transfer Act, the Army could provide the curriculum and training support materials to the schools. In the future this would include a high school link up to an Army Distributed Training Network.

As an incentive, the recruiter could offer a "summer job option", using existing federal programs, to those willing to sign a letter of intent to enlist after graduation. (Could be either active or reserve commitment). During the summer, student could attend Basic Training and/or participate in a on-the-job training program with either an active or reserve unit. This would provide an opportunity to hone those skills learned during their junior year. During this period, they would draw E-1 pay to begin and E-2 pay at the end of the summer or the BCT phase. In their senior year, they would resume the program. Upon graduation, they could be promoted to E-3 and PCS directly to the unit for a two-year enlistment. It is envisioned that they would enter the service with most Skill Level Two tasks trained. Introduction of such a program has both direct and intrinsic benefits:

a. For the Army:

-- Provides a competitive edge with industry to better tap a dwindling recruitment pool.

-- Provides for PCS directly to units after graduation.

-- Reduces the resident training base and the costs associated with training skill level one tasks.

-- Creates an infrastructure of civilian who are pro-Army.

b. For the individual:

-- Instills self-discipline at a critical time in the adolescents maturation process.

-- Has the potential of reducing the high school drop-out rate.

-- Provides job opportunities for various minorities.

-- Boister economically deprived areas and reducing racial tension.

See Figure 4.

<u>Preaccession Model (Delayed Entry)</u> As the force structure declines it appears that the delayed entry program will become the norm. An architecture could be developed which would capitalize on this "dead time" by providing training. This training could be structured or simply made available at military learning centers or recruitment centers.

<u>VOTEC TRAINING</u>

o Unstructured
-- Installation Learning Center
-- Take Home Instruction (i.e. Off-Shelf electronics courseware)

o Structured
-- Attends VOTEC
-- Establish Recruiter/ MEP Learning Centers

See Figure 5.

<u>Industry Model</u> The industry model (train now, pay later) takes advantage of existing training. It suggests that the Army can recruit those already possessing some or all the skills associated with skill level one training in certain MOS. This could be accomplished through the development or purchasing of achievement tests to certify competency in selected skills prior to recruitment. Tuition reimbursement and advanced promotions could be offered as enticements for enlistment. In some MOS the Army should be able to compete favorably with industry to recruit recent VOTEC graduates. Some examples of MOS which fall into this category include all 19 band MOS and the military police MOS (95B10).

See Figure 6.

<u>Post Accession Model</u> After an individual comes on active duty several options exist for utilizing VOTEC. A soldier could be sent to a VOTEC center for training in his local community prior to BCT. After completing the VOTEC training he would PCS to his BCT station then to his unit. A variation could occur where an individual is sent to BCT than PCS to his first assignment where VOTEC training could be used, if available, to train the MOS. Both options have monetary advantages over the current system. Still another option would have the VOTEC portion of training occur after BCT but at the same locale. All the options above save substantial costs in PCS moves over our current system.

Contract Training Many of the models above include some aspects of contract training. The training for various technical skills such as diesel mechanics, heavy equipment operators, nursing, language, etc. are "light green" and could be economically contracted out. Contract training could occur at service schools, corporations, or public or private institutions. Some concern has been raised that IET soldierization would be lost if such a system were adopted. This could be avoided by contracting for the technical training prior to basic combat training paving the way for direct PCS to the unit. (This presupposes that most soldierization occurs in BCT.) Soldierization could also be preserved by assigning personnel to an RC Unit for basic soldiering training, (i.e., care and feeding of the uniform and for command and control). Upon completion of technical training, an individual would complete basic training and either report directly to a unit for "greening" of the technical training in the functional context of a unit/tactical environment.

Certain benefits can be derived from adopting such a system. In our current system, personnel have three difficult simultaneous learning experiences. They are learning an MOS and how to be a soldier. At the same time, they are learning a foreign language; military and technical jargon. The requirements of soldierization are often physically, mentally, and emotionally taxing. This hampers a soldier's ability to learn. In adopting the concept proposed, soldiers would concentrate on developing technical proficiency in a non-threatening environment. It would also reduce our operational costs at the service schools and TDY and PCS expenses. In many cases, these savings would offset the cost of the contract training. Improved accountability for training would also result as this would be a factor for the awarding or maintaining of a contract.

As a final consideration, the services provided by the light green CMFs could be readily contracted out to the civilian sector and certain MOS eliminated from the active force structure. As a wartime buffer, a provision to the contract could require a certain percentage of the personnel providing the services to be members of the Reserve Component. Thus, a sustainment environment is created where personnel in the reserves practice their wartime skills on a daily basis. (A variation of this theme currently exists: Civilians hired by the reserve in many cases must be reservists.)

Summary From a personnel management perspective, many of our current conventions need to be reassessed. Trainers, recruiters, and personnel managers must work more closely in developing "cradle-to-grave" continuums which provide maximum return for training dollars invested.

Innovative recruitment procedures, focusing recruitment on "low-cost" MOS, creating MOS merger patterns which transition personnel to higher cost MOS during their second enlistments can all result in training savings.

New screening instruments, which measure both cognitive and psychomotor achievement/ abilities, will better match the individual to the occupations and reduce reenlistment retraining costs. In an era of constrained budgets, policies and procedures to reduce low reenlistment rates for many MOS must be developed. This will promote a maximum return on our investment in front-end training costs.

As the size of the Army decreases, the need for higher quality, more experienced personnel increases. In this regard, the current "up or out" policy needs to be reexamined as does the "Specialist Rank." There appears to be a need for the career technician especially in the high tech CMFs where proficiency is gained through years of experience.

By leveraging recruitment, the Army should recruit individuals with as many of the entry skills and knowledges as possible to reduce the front-end costs of initial entry training. Focal point of these recruitment efforts should be in the high density low-tech, inexpensive to train CMFs.

Finally, although the square was originally conceived as a vehicle to model training strategies it has proven useful in other respects. During the analysis of the MOS characteristics, it became apparent that differences in the leadership types and styles associated with supervising personnel in the various occupations should exist. The psychological profiles of leaders in each of the squares also seem different. Future efforts may yield a leadership task inventory corrolated to the requirements of each quadrant. The square has also been used to focus at least at a macro-level the types of technologies which we should be exploring with each group of CMFs. For instance, artificial intelligence training technologies maybe overkill for training purposes for some of the CMF which have low technical requirements. Generally speaking, the need

for more sophisticated training aids, devices, simulations, and simulators increases in a counterclockwise direction as one moves around the various quadrants. Again, further work is warranted in the arena to determine the utility of using the square to focus technological applications.

The paper reflects the views of the author and should not be construed as Official Department of the Army Policy or Doctrine.

CMF Clusters

GREENESS / TECHNOLOGY	LOW TECHNOLOGY	HIGH TECHNOLOGY
DARK	CMF-11 INFANTRY CMF-12 COMBAT ENGINEERING CMF-13 FIELD ARTILLERY CMF-16 AIR DEFENSE ARTILLERY CMF-19 ARMOR CMF-28 AVIATION COMMO. ELECTRONIC MAINTENANCE CMF-29 COMMUNICATION ELECTRONIC MAINTENANCE CMF-31 COMMUNICATIONS ELECTRONIC OPERATIONS CMF-54 CHEMICAL CMF-55 AMMUNITION CMF-76 SUPPLY & SERVICES CMF-77 PETROLEUM & WATER CMF-79 RECRUITING & REENLISTMENT	CMF-18 SPECIAL OPERATIONS CMF-23 AIR DEFENSE SYSTEM MAINTENANCE CMF-27 LAND COMBAT SYSTEM INTERMEDIATE MAINT. CMF-33 ELECTRONIC WARFARE INTERCEPT MAINTENANCE CMF-67 AVIATION MAINTENANCE CMF-93 AVIATION OPERATIONS CMF-96 MILITARY INTELLIGENCE CMF-98 ELECTRONIC WARFARE CRYPTOLOGIC OPERATIONS
LIGHT	CMF-25 AUDIO-VISUAL CMF-46 PUBLIC AFFAIRS CMF-71 ADMINISTRATION CMF-88 TRANSPORTATION CMF-94 FOOD SERVICES CMF-95 MILITARY POLICE CMF-97 BANDS	CMF-51 GENERAL ENGINEERING CMF-63 MECHANICAL MAINTENANCE CMF-74 AUTOMATIC DATA PROCESSING CMF-81 TOPOGRAPHICAL ENGINEERING CMF-91 MEDICAL

LOW — TECHNOLOGY — HIGH

DARK — GREENESS — LIGHT

CMF-CAREER MANAGEMENT FIELD

FIGURE 1

CMF-16 Air Defense Artillery

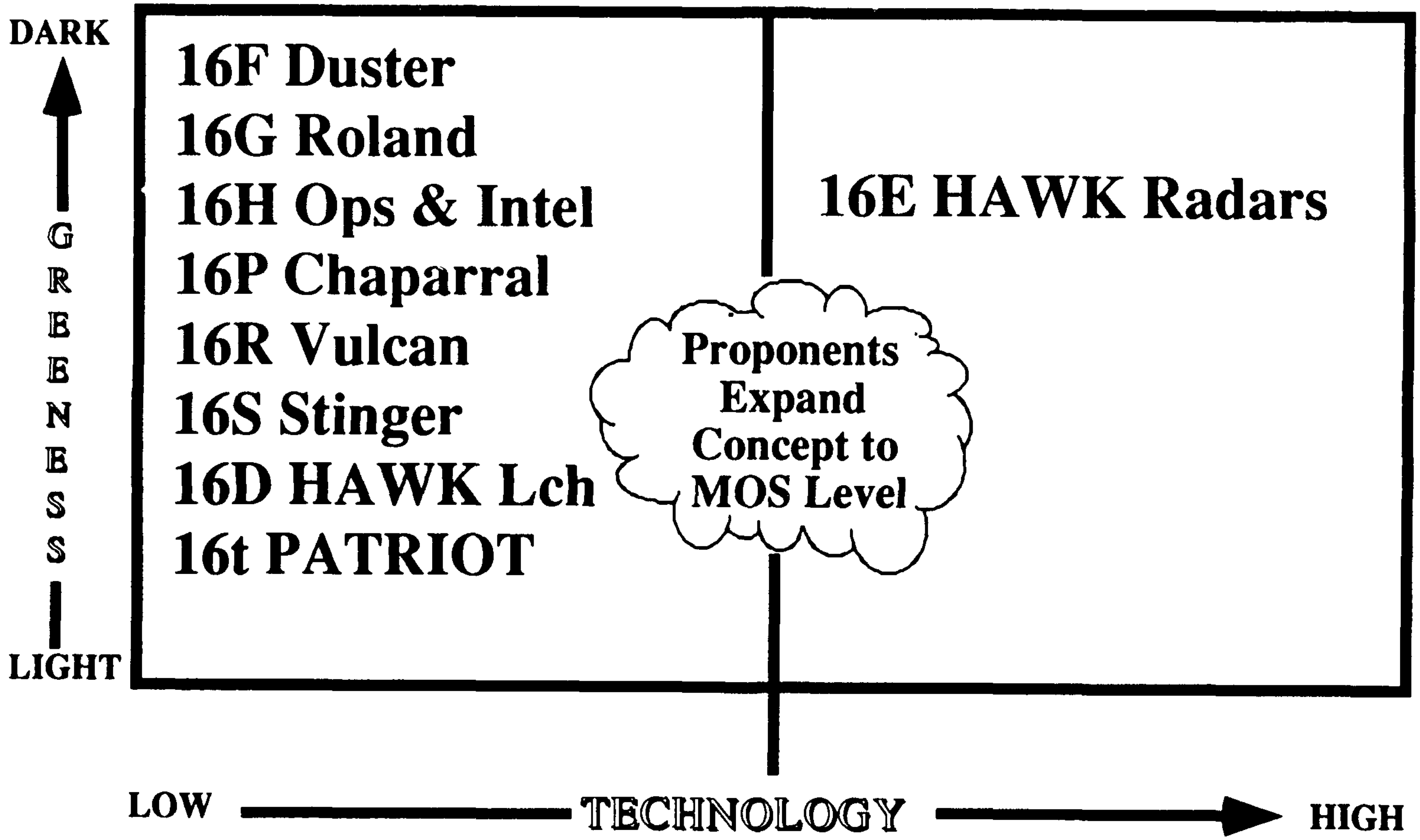


FIGURE 2

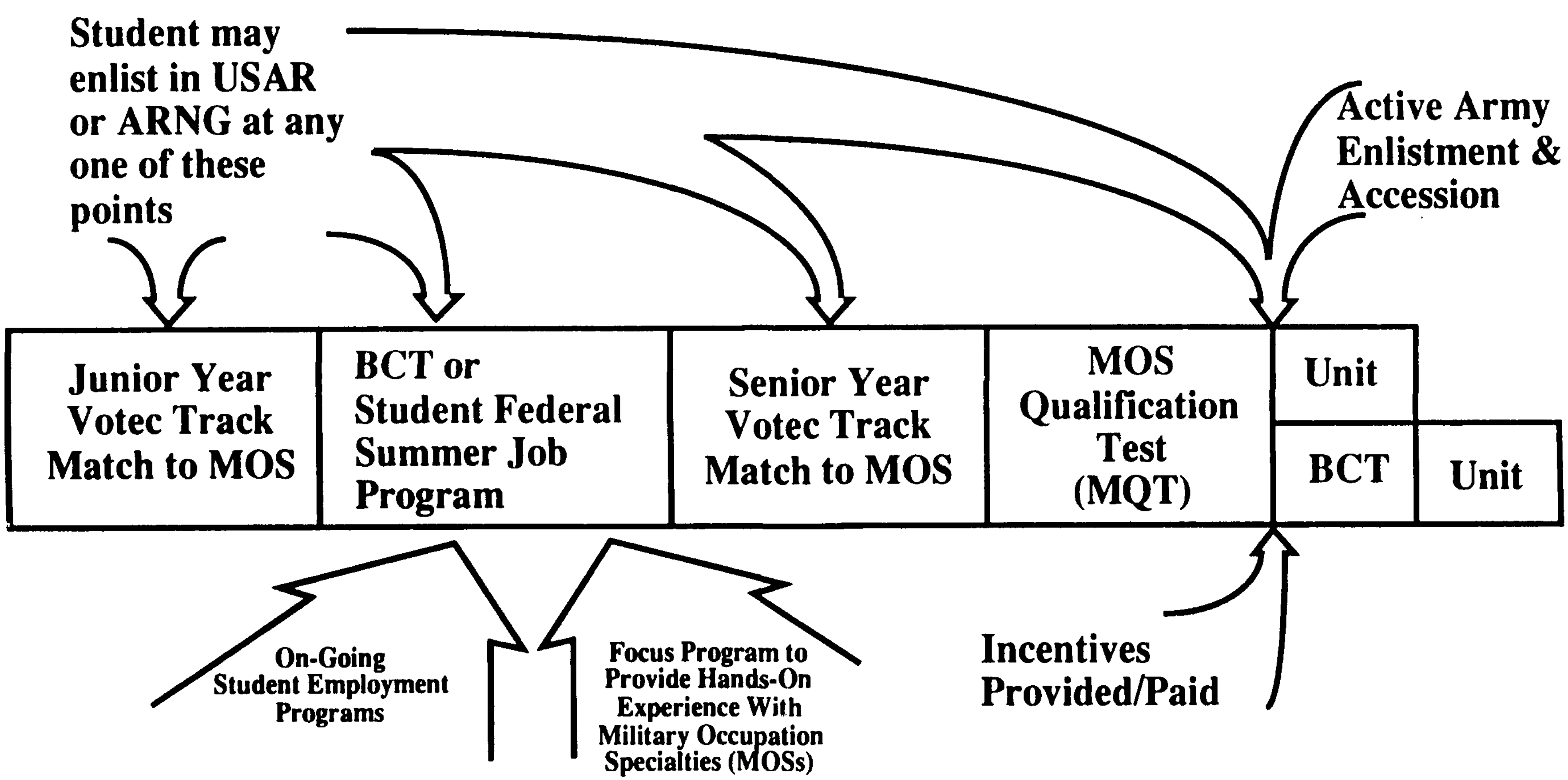

Student may enlist in USAR or ARNG at any one of these points
Active Army Enlistment & Accession
Junior Year Votec Track Match to MOS
BCT or Student Federal Summer Job Program
Senior Year Votec Track Match to MOS
MOS Qualification Test (MQT)
Unit
BCT
Unit
On-Going Student Employment Programs
Focus Program to Provide Hands-On Experience With Military Occupation Specialties (MOSs)
Incentives Provided/Paid

FIGURE 3

Prospect	Applicant	Enlistee	
Delayed Entry Training		BCT	Unit or Abbreviated AIT
Local Recruiter	MEP Station	Service School	

VoTec Training
- Unstructured
  - --Installation Learning Center
  - --Take Home Instruction (ie. Off-Shelf Electronics Courseware
- Structured
  - --Attends VoTec
  - --Establish Recruiter/MEP Learning Centers (Off-Shelf Courseware)

FiG 4

FIGURE 4

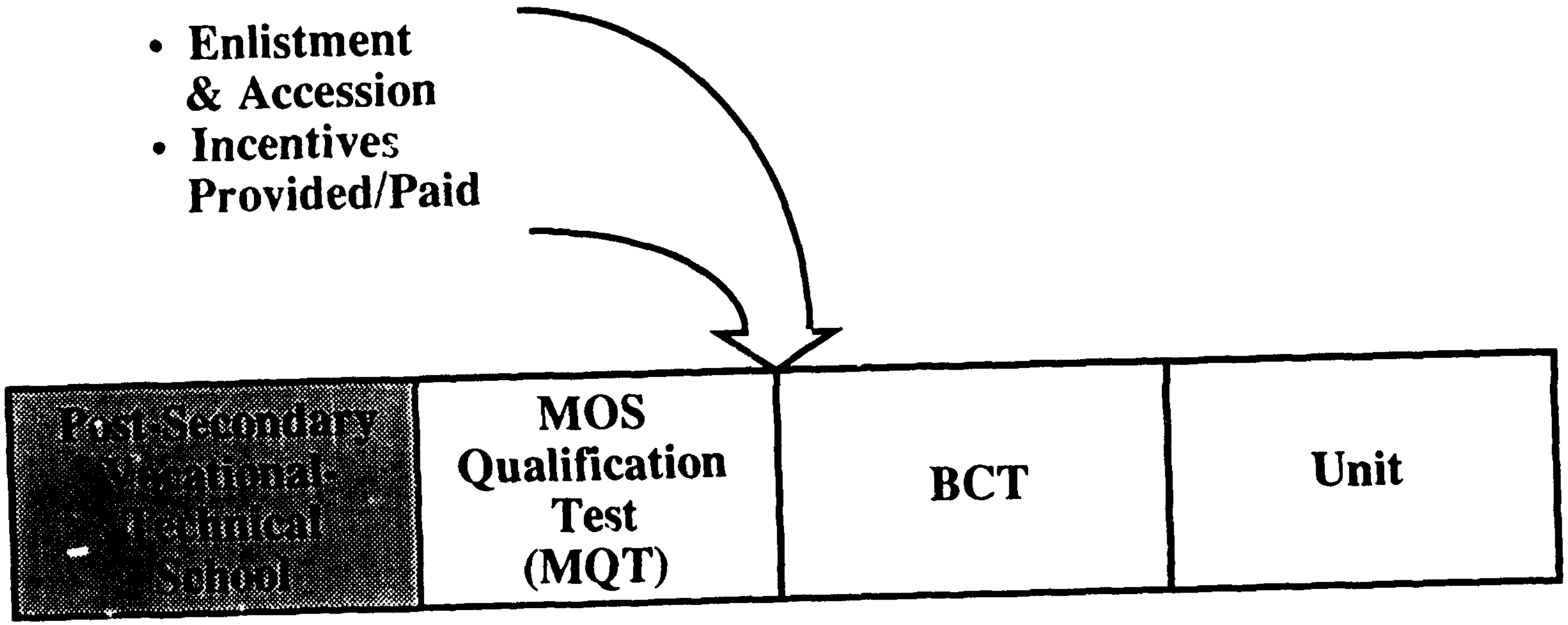

• Enlistment
& Accession
• Incentives
Provided/Paid
Post-Secondary
Vocational-
Technical
School
MOS
Qualification
Test
(MQT)
BCT
Unit

FIGURE 5

WHAT DOES THE RESEARCH LITERATURE TELL US ABOUT ADOPTING INNOVATIVE TECHNOLOGIES?

P. Kelly Watson, Ph.D.

The study of the adoption and use of innovation and technology is relatively new, most of the research being 30 to 40 years old. However, there seems to be no single "grand theory" that explains a significant portion of the variance found in studies of the adoption of innovations. The research studies are often either too general and/or descriptive in their results and methods, or too specific to generalize to other settings. There are, however, some findings that seem to have relevance for many developers and users of new technologies and innovations, regardless of the setting. The purpose of this paper is to: 1) provide a definition and description of the process of innovation and change; 2) provide the results of research studies of adoption and use of innovations, especially those in training and education, including specific examples from military settings; and 3) provide a set of guidelines generated from the research findings that can be used to plan for adoption and use of innovations and new technologies.

The process of creating innovations and getting people to use them is the process of changing behavior, often on a mass scale. Therefore, the research results covered in this paper will be presented as they relate to behavioral change, using the stimulus -organism - response - consequence (S-O-R-x) model as a typology. Thus, the research findings and examples will be presented as stimulus attributes (e.g., attributes of innovations, characteristics of change agents); as organizational and individual attributes (e.g., personality characteristics; cultural, social and organizational factors); and as behavior attributes and consequences (e.g., implementation and use, rewards and punishments for use). Guidelines for ensuring successful change or adoption will be presented as planning questions, formatted within the same typology that was used to present the research findings. These questions, when combined with context-specific criteria, could provide the basis for a set of procedures for the systematic planning and design of the innovation adoption process.

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WHAT DOES THE RESEARCH LITERATURE TELL US ABOUT ADOPTING INNOVATIVE TECHNOLOGIES?

P. Kelly Watson, Ph.D.

Introduction. The field of education has produced the greatest number of studies on the dissemination and use of knowledge and innovation, but perhaps no other field has benefitted less from the process. Although the quantity of studies is great, the quality has been decidedly less than hoped for. In part, the reasons for this lack of contribution have been associated with the unique properties of educational organizations and procedures, the variety and types of "change agents", and the nature of the user groups. Training, as a subset and special case of education, shares some of the same problems. In some cases, the problems are exacerbated by the fact that training shares the bureaucratic characteristics of both educational and non-educational organizations.

There are features of the research on innovation and change that are applicable to education and training settings, however. Dill and Friedman (1979), in their review of innovation and change literature, have noted that the characteristics that describe change in education are essentially the same as those that describe change in other disciplines. What varies is the methodological rigor, the terminology, and the theoretical framework associated with the researchers. Rogers and Shoemaker's definitive work on change and innovation (1971) suggests that there will ultimately be a convergence of research orientation in this field (the "middle range analysis") that will occur due to the diffusion of information across and among disciplines. Because the research tends to be either very theoretical and descriptive, or very empirical and lacking in conceptual and theoretical structure, Rogers and Shoemaker have proposed the generation of research that results in propositions midway between specificity and generality. These propositions may then be used to bridge the gap between theory and empirical findings, and may provide a means of integrating the diverse research traditions found across various disciplines.

This paper represents an attempt at this middle range, in that the framework and concepts presented are derived from various theoretical positions, while the importance and contribution of the concepts are results of empirical studies that support the inclusion of the concepts. The paper is centered around the concept of innovation as it represents planned, purposive change. This change is often in the form of new technologies, such as computer technologies. When people or organizations fail to adopt innovations, however, they usually do so for specific reasons. Therefore, the real

study of innovation is the study of resistance to and acceptance of change.

Innovation, as planned change, is intended to bring about improvements in individuals or social/organizational systems. The concept of planned change assumes that, in addition to a recipient of such efforts, there are those individuals and organizations (known as change agents) that attempt to instill these changes in such recipients (known as clients or users), and that these agents meet with varying degrees of success or failure due to several factors (to be addressed in this paper). It is important to note, however, that for an innovation to be perceived as truly "innovative", it must be perceived as new and/or unique by members of the organization or group who comprise the group's adopting unit. In some instances, the "newness" of an innovation may be nothing more than a new, previously non-existent attitude toward the idea or innovation that is expressed by the adopting group, but even this has implications for whether the group may accept the change or reject it.

The Process of Change. There are several paradigms used to describe the change process. In simple terms, Rogers and Shoemaker (1971) suggest that the change process is one of communication, in which a "sender" (S) gives a message (M) through a particular channel or medium (C) to a receiver (R), resulting in some effect or consequence (E) (the S-M-C-R-E model). This model has been adapted in this paper to correspond to a traditional stimulus-organism-response-consequence learning model (S-O-R-x); thus, sender characteristics, message or innovation type, and media are subsumed under stimulus characteristics (S), receiver characteristics are subsumed under individual and organizational/social variables (O), and effects are covered by the response and consequences of the response (R).

If the communication process is intended to bring about purposeful change such as the adoption of a new technology, it may be described as a sequence of stages in which the innovation is either subsequently adopted or rejected. Rogers and Shoemaker describe the stages of adoption as follows:

1) **Knowledge** - Awareness of an innovation is created and the adopter acquires some understanding of the functioning of the innovation. Preceding this stage are those individual and organization constructs that affect, in theory, the further processing of the change/adoption process (e.g., individual personality traits, social, organizational, and cultural characteristics, needs of adopters, etc.).

2) **Persuasion** - Attitudes are formed about the innovation as a result of the information acquired.

3) **Decision** - An individual or

organization forms a decision concerning adoption or rejection; the type of decision-making process (e.g., democratic vs. authoritarian) is a major determinant of acceptance.

4) **Confirmation** - Adopters seek reinforcement for a decision concerning adoption which may result in continued use or discontinuance of the innovation.

Hall, Loucks, Rutherford, and Newlove (1975) developed a model that describes the extent to which teachers use innovative materials. The model, called the "Levels of Use" model, entails eight levels within seven distinct stages that describe a continuum of use. The self-explanatory stages are: **non-use, orientation, preparation, mechanical, routine and refinement** (two levels within the same stage), **integration** (with ongoing methods), and **renewal**. The model assumes that some innovation has been introduced to the instructor's organization or school, and that resistance to or acceptance of the innovation can be described by demonstrated behavior of teachers or instructors that use the method or product to varying degrees.

Similar to the Levels of Use model is the model of "Stages of Concern", also developed by Hall and Loucks (1978). As with the Levels of Use model, innovation usage is described and classified <u>after</u> it has already been adopted. This model was developed to attempt to identify attitudes and concerns of teachers regarding the use of innovations, rather than as a means for classifying their extent of use. In this model, the stages are:

1) **Awareness** - No knowledge about specific characteristics.

2) **Information** - Seeking and receiving information about the innovation.

3) **Personal** - Concern about how the use of the innovation will affect the potential user.

4) **Management** - Concern about the extent of time spent using/supporting the innovation.

5) **Consequence** - Concern about the impact of use on end-user (e.g., students).

6) **Collaboration** - Concern about relating what is known about the innovation with peers.

7) **Refocusing** - Concern about changes and enhancements to the innovation and its use.

Although the orientation of the two Hall and Loucks' models are levels of use and expressed concerns rather than the change process itself, there are obvious similarities. In addition to the rough parallel to the events described in Rogers and Shoemaker's model, the stages described in both models also describe empirically-derived stages. The use of "stage"

approaches is common in the literature on innovation and change, and is an attempt to categorize the common steps that occur when individuals and organizations are faced with purposive change. Figure 1 shows the models described above and their process and stage similarities. Perhaps the simplest description of the processes involved in change and adoption of innovation is provided by Stoffer, Blaiwes, and Brictson (1980); their "acceptance process" model shows a "unfreezing - changing - refreezing" sequence of behavior that must occur during the process of change (adapted from Lewin, 1951). Their conceptualization of the change process will be covered later in this paper as a means of summarizing some of the issues involved in the adoption of innovations.

In addition to the study of change as a function of individual behavior, there has been a considerable effort to study change as a function of organizations or social systems. Katz and Kahn (1966), for example, view the change process as much more a province of organizations than of individuals alone. Their conceptualizations have shown that organizational factors must be included as variables contributing to the change or adoption process. They cite as examples of their point the common practice of taking managers and foremen out of organizations in order to receive training in some new method designed to increase productivity, improve worker relations, or both. When these methods fail to bring about the desired changes, the authors charge, the reasons are often due to an attempt to make changes <u>only</u> at the individual level without a corresponding attempt to address organizational factors at the same time.

Whereas factors related to individuals and their adoption and use of innovation are relatively specific and empirically derived, organizational variables are often general, harder to validate, and thus less subject to control and prediction. However, there is sufficient evidence to suggest that they have importance to the study of adoption and use. The middle range analysis described earlier may also provide a means of incorporating specific individual variables with more general organizational variables as a means of explaining more of what is observed in real-life settings, if for no other reason than because reality is often too complex to be explained by one approach. The guidelines provided at the end of this paper should help by offering planners of change a list of variables (as well as an organizing framework) to use in designing the dissemination of new technologies.

The implications of the previous points are that many variables may be linked to adoption or rejection of innovations. Those variables that have the most empirical

support and/or relevance will be presented in this paper. The S-O-R-x paradigm will include attributes of innovations and characteristics of change agents (S); social, organizational, and individual characteristics (O); and innovation implementation and consequences of use (R-x). The final section of the paper will suggest methods of increasing the probability that a particular innovation will be successfully implemented, and will include the guidelines for planners.

Stimulus Attributes of Innovations Rogers and Shoemaker (1971) have succinctly pointed out that the adoption or acceptance of an innovation is related to the characteristics of the innovation, not as seen by experts but as perceived by potential adopters. They have analyzed the literature on change across several disciplines and have generated distinct categories of attributes. The attributes are listed below, and discussed in subsequent sections.

1) **Relative Advantage** - the degree to which an innovation is perceived as being better than the idea it supersedes; often measured by variables such as cost-benefit ratio, labor requirements or increases, perceived risk, etc.

2) **Compatibility** - the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of the receivers.

3) **Complexity** - the perceived quality of difficulty in understanding and/or using the innovation.

4) **Trialability** - the extent to which an innovation may be tried on a limited or temporary basis; **reversibility** (Zaltman, Florio and Sikorski, 1977) is one facet of this, in that an innovation is irreversible if discontinuation of its use is difficult or impossible; **divisibility** of innovations is another facet that increases the probability of adoption.

5) **Observability** - the extent to which the results of an innovation are observable, noticeable, or communicable to potential adopters (thus supporting the finding that material innovations are more readily adopted than are nonmaterial ones such as ideas or procedures).

Other attributes suggested as determinants of adoption are the **radicalness** of the innovation (i.e., how novel, creative, and risky the innovation is and how much of an impact it is likely to have on its users), and the **scientific status** of the innovation (Zaltman, Duncan, and Holbek, 1973; Havelock, 1979). This latter factor is especially important for educational and training innovations, because it involves the perceived worth of the innovation in terms of its validity, reliability, internal consistency, and

empirical support. Perhaps one of the more famous (or infamous) variables is the **point of origin** of the innovation: where does it come from? The "not invented here" syndrome is an example of resistance often demonstrated for innovations whose points of origin are outside organizations.

In his extensive review of factors affecting utilization of innovations, Burkman (1987) suggests that, of the factors described above, the most important one for training and instruction innovations is **relative advantage**. He lists the issues related to perceived relative advantage from two different perspectives: the instructor's and the organization's (specifically, the decision-makers').

Instructors tend to view innovations and their relative advantage according to: 1) the amount of work associated with the use of the innovation, and 2) the effect of use of the innovation on their relationships with learners. Therefore, instructors may tend to reject or modify innovations under the following circumstances:

o If using the innovation might reduce instructor-student interaction, or involve self-instruction, since instructors tend to prefer personal interaction with students and group instruction.

o If there is a increased management function associated with the innovation, since instructors believe that they have little extra time available for scheduling, record-keeping, etc.

o If there are materials associated with the instructional innovation that are perceived as inappropriate for the student's level or that lack motivational features, since instructors want to motivate their students to perform better.

o If the materials are perceived to be of insufficient quality to achieve the stated objectives (usually an intuitive decision).

Decision-makers within educational and training organizations use somewhat different attributes to determine relative advantage, as might be expected. They may reject or modify an innovation under the following circumstances:

o If the cost of the innovation is out of the scope of the budget (probably the most common reason) or if the use of the innovation requires additional resources such as personnel, equipment, etc.

o If the innovation will not enjoy a wide degree of acceptance among users in the organization, or among the organization's benefactors and clients (this is closely allied with the issue of **compatibility**, previously mentioned).

o If the innovation is not

perceived to be of sufficient quality to achieve student learning (i.e., to be efficient and effective).

Johnson (1988) has provided support for the kinds of issues likely to be factors in adoption and use described in Burkman's review. In his review of the problems associated with fielding more intelligent tutoring systems (ITS's), Johnson cites four categorical reasons (combined below into two major categories) why few ITS's survive the transition from R & D settings to practice:

o Resources - shortages in qualified personnel, as well as necessary hardware and software, are often combined with insufficient funding (most ITS development is funded through R & D funds, which are notoriously inadequate); these problems affect both the development as well as the implementation of the ITS.

o Attitudes - both developers and sponsors often display attitudes about the quality and amount of the ITS developed that suggest less than adequate accountability for their products, which may in turn lead to lower quality products.

These two kinds of problems would be predicted by Burkman's review as the kind of problems or issues associated with rejection of ITS's or other technological innovations by user groups such as instructors and managers.

Another example of resistance can be seen in a study by Evans (1968). The author presents a case study of the resistance to instructional television (ITV) by faculty members at a metropolitan university. The results of this investigation showed that resistance (as measured by responses to attitude questionnaires and surveys) was increased by four major perceptions of ITV:

1) Compatibility - Most faculty members expressing negative attitudes believed that ITV was not compatible with "good teaching" practices which they believed required direct student-faculty interaction.

2) Complexity - Resistant faculty members believed that ITV was too complex and required training and technical expertise they lacked.

3) Divisibility - Some faculty members stated that they would only be interested in ITV to the extent that it could be broken down into palatable bits and used as an adjunct to on-going teaching activities.

4) Point of origin - Acceptance and rejection of ITV was often found to depend on whether faculty members perceived the idea to have originated within their own departments (as part of their own planning efforts), or imposed on them by the university administration.

Attributes of innovations are

often brought to the attention of potential users by the deliberate efforts of change agents. Change agents may be defined most simply as individuals who strive for the improvement of some agency, institution, or group that they believe would likely benefit from the adoption of an innovation. Therefore, what people perceive as the attributes of new products, ideas, or technologies are often directly the result of active participation by some change agent, either within or outside of the organization or group. (Note: Earlier mention was made of channels of communication and their role in change. Of the two major channels of communication - interpersonal and mass media (newspapers, television, radio) - change agents are more apt to be successful in implementing change when using interpersonal channels of communication. For this reason, the focus of this section will be on the use of interpersonal channels by change agents rather than on mass communication.)

What makes people who act as change agents successful? Watson (1981) has reviewed the characteristics and actions of successful change agents, presented below:

1) Change is almost directly related to the level of effort put forth by the change agents: the more effort, the greater the chance of success.

2) Change is more likely to occur when change agents perform according to the role expectations of the clients rather than the change agencies.

3) Change is more likely when the advocated solution or innovation is perceived to address a real problem rather an assumed one.

4) Successful change agents are empathetic, credible, and share similar attributes and traits with their clients.

5) Change agents meet less resistance and are more often successful if they first approach opinion leaders rather than non-leaders within the organizations in which change is introduced.

6) Change agents are more successful, both immediately and in the future, if they increase the client's ability to evaluate innovations (evaluation ability is positively correlated with proper usage of the innovation).

7) Resistance to change and innovation is lessened when change agents involve their clients in the development or creation of the innovation or change, if they anticipate and address sources of resistance before they arise, and if they point out the long term benefits of the proposed innovation to the clients.

8) Resistance to change is lessened where change agents can work as a team rather than as individuals.

In summary, what change agents

do is to introduce and work for the adoption and use of a new product, idea, or procedure. They are most effective in accomplishing change when they are members of the organization in which change is introduced, when they reflect personal characteristics that admired and/or shared by users, if they involve users to some degree in developing and using the innovation, and if they are proactive in identifying and resolving potential problems with adoption and use of the innovation. All of this assumes that the innovation that is being promoted is an acceptable solution to a real problem or need in the organization.

Before moving to the next category of variables, it should be mentioned that the discussion of the innovation and change process assumes what Rogers (1976) calls a "pro-innovation bias". That is, the research literature and the approach taken to the issue of change assumes that change is good, that those who do not accept the innovation "resist" or "reject" some presumably good development. This is obviously not always the case, but it is characteristic of Western cultures and societies that are, to a large extent, products of technology. Change and new technology are everyday aspects of life here, but not in other countries or even all socioeconomic groups in a given Western country or society. What often happens, therefore, in studies of innovation is that there is a presumption that failure to adopt and use new products or procedures is due to an inherent attitude of resistance to all new things, or due to some other individual flaw in the personality of the potential user. The next section looks at both individual variables and organizational/social variables that may be associated with resistance to or adoption of change and innovation.

Organizational and Individual Variables In the previous section, cultural differences both between and within groups were suggested as reasons why innovations are rejected or not used. Such culture "gaps" may also be found in education, the military, or industry, where organizations and groups are described by their own organizational cultures. The construct of "organizational culture" is one that can be used to characterize most organizational and social variables affecting acceptance and rejection of innovation, including social norms and expectations, group cohesion, and the function of the organization in society. One of the more difficult problems with describing organizational barriers to adoption and use, however, is the fact that the variables exist as hypothetical constructs, i.e., there is usually no way to directly observe and validate their existence or their importance. However, these variables are at least valuable methods for describing what seems to be

occurring in organizations faced with the introduction of innovation. The variables that have the most relevance to resistance and acceptance of innovation follow.

Because all organizations create and maintain their own barriers to other organizational influences, separate cultures are often created, reflecting their unique characteristics. This culture may result in its members viewing other cultures as inferior to theirs, and this sense of superiority may often intentionally or unintentionally be communicated to others. Sarason (1971) has discussed this problem in the context of schools, and notes that it is most common to the university researcher - school practitioner relationship. Because they view the cultural milieu of public schools as inferior to their own highly academic, prestigious culture, researchers often look down on teachers and administrators and, as a result, experience resistance to university research and its results. Moreover, this problem is found in other organizations in which user groups, practitioners, and clients are recipients of research studies intended to bring about changes in their organizations. Thus, culture gaps that exist because of the intentional segregation of one culture from others can result in problems when there is an attempt to communicate or provide assistance to others. Even in those academic settings in which such distinctions are minimal, there may still be a culture gap if researchers or innovators fail to include their clients in the developmental process of creating change (Zaltman, Florio, and Sikorski, 1977). When such exclusion occurs, clients may find it easy to disregard or reject the innovation since there is no ownership of the plan (cf. Drucker, 1973).

Havelock's analysis of the change process is useful for describing how organizations, as systems, may block or inhibit innovation use (Havelock, 1979). When viewed as a system, the organization functions by input of materials and information. Thus, the first point of resistance may be the blocking of information into the organization. Some of the variables that may explain information blocking are listed below:

o **Desire for stability** - Most organizations require stability in order to function properly; innovative practices are, almost by definition, destabilizing since they call for the implementation of new ideas and methods. Stability is a factor that seems to act as an informational "gatekeeper" in that it is a value acting as a barrier to change. When the desire for stability yields lethargy and insulation, however, it may result in the organization's becoming entrenched in the technological Dark Ages. Perelman (1990), for example, offers an anecdote concerning

the reaction of school administrators to an interactive video system that could increase productivity in adult learning settings by 30% and decrease time required to complete courses: the administrators rejected the system because "the district pays us for attendance, not achievement....if anything my ADA (average daily attendance) might go down and my budget could get cut".

o **Coding scheme barriers** - All organizations create their unique language and jargon. When organizations want to block innovational input, they may use coding scheme barriers (i.e., communication barriers such as recognition of specific terminology only) as a means of rejecting potential innovations.

o **Financial conditions** - Havelock notes that organizations that are not financially secure are often resistant to innovation because they can't afford the expense or resource commitment to make changes. On the other hand, Havelock reports that financially secure organizations are often those that are most open and receptive to innovation.

o **Training and staff development** - Organizations that provide formal training and development for their employees often teach the status quo, and instruct "appropriate" attitudes for resisting change.

o **Organizational vulnerability** - Sieber (1967) describes educational organizations (and, by extension, training organizations) as **vulnerable** organizations. Vulnerability is defined as the "probability of being subjected to pressures that are incompatible with one's goals without the capacity to resist". Because training and education organizations serve clients within the larger organization or community, they must be responsive to the constantly changing demands of their clients, even if the wishes of the client are at odds with the goals and procedures of the serving organization. Such adjustments to the demands of the client create strain and tension within the organization, and there is a resultant lag between what the organization does and what is expected of it. Such lags create even more pressure for change. The result of such conflict is twofold: 1) a general resistance to innovation and change overall, and 2) an acceptance of those innovations or changes desired by client organizations, almost regardless of merit.

Resistance may also occur as a result of the internal functioning of the organization - the system "throughput", in systems theory terminology. This refers to the flow of information and the major processes that are routinely ongoing. The decision to innovate or adopt some change in procedures is the focal point around which the variables related to

resistance are spread. The most important variables are listed and described below:

o **Type of decision-to-innovate** - In formal organizations, decisions made concerning the adoption of innovations are typically of two kinds: authority innovation-decisions, and collective innovation-decisions. As the name implies, authority decisions are made by those in positions of power and imposed on the organization, while collective decisions are made by consensus of group members. Rogers and Shoemaker (1971) have stated that the attitude of the adopting unit toward the innovation is highly related to the type of decision process used to implement the change: authority innovation-decisions tend to generate resistance among users, as well as what Rogers and Shoemaker call innovation dissonance. This concept, like cognitive dissonance (cf. Festinger, 1957), suggests that there is a discrepancy between the behavior required by users of an innovation and the user's attitudes toward the innovation. Dissonance theory predicts that either the behavior or the attitude would change as a result of such dissonance; reducing the dissonance, then, often leads to discontinuation of use of the innovation, or at best a reduction of use overall.

o **Status differences among groups** - In those organizations in which there are differences in status among the groups comprising the organization, there is likely to be a status hierarchy. In such organizations, high status or authoritative members are less likely to accept information if it comes from those lower in the organizational hierarchy, despite the fact that those lower in the hierarchy may be more in touch with critical issues of performance than high status members. In some cases, whole groups enjoy higher status than other groups, and this relationship can impede the process of adoption or use of innovations. A good example of group status differences as barriers to change can be seen in large defense contractor corporations. In most, if not all, of these organizations, the most prestigious and highest status group is the engineering division. Thus, engineering organizations often dictate inappropriate or incomplete solutions to problems, as, for example, in cases in which the project is a training development project. Since most training organizations historically are low in organizational status, training projects are designed and developed according to engineering principles rather than training needs and requirements. This results in disregard for training information or innovative approaches if they are not part of, or consistent with, the engineering domain.

o **Existing job roles** - Most organizations reward personnel only for what they are doing now. Existing tasks and jobs

typically define the roles of workers but do not provide rewards or support for innovation or new ways of functioning. This essentially encourages workers not to rock the boat. Again, Perelman (1990) offers an example of this kind of barrier. He interviewed teachers in one of the country's most affluent school districts to determine why there had been so little teacher interest in a large program involving computer-aided instruction. One teacher responded " Why should I do anything different next year from what I did last year? Who cares?" Part of this attitude was a result of the school bureaucracy's failure to support or reward innovation in the classroom.

Psychological studies have provided many possible variables and concepts that could be used to explain why people change or fail to change their behavior. In social psychology, for example, consistency and balance (McGuire, 1972; Heider 1958) have been identified as motivating factors in humans to explain why people tend to behave in ways that minimize drastic changes to their lives. Maslow (1954) attempted to explain the desire for stability and need fulfillment by suggesting a hierarchy of needs that humans strive to meet. The individual's needs, combined with a general desire to maintain a physical and psychological steady state, may lead to the individual's acceptance of those objects or activities in the environment that meet the most basic or immediate needs. Thus, the more relevant innovations are to specific individual needs, the more likely they are to be accepted (Havelock and Benne, 1967). Such explanations support the well-known concept of homeostasis, which suggests, in part, that humans seek balance and minimal disruption of their lives.

Consistency of behavior, however, does not suggest that individuals who adopt an innovation will continue to adopt other innovations. Rogers and Shoemaker (1971) have stated that individuals tend to shift from adopter to non-adopter categories with some regularity, making it difficult at best to predict with any degree of certainty whether an individual who has accepted an innovation will adopt other innovations in the future. They suggest that consistency of innovativeness is more likely to be seen in individuals adopting consumer or material innovations rather than less tangible changes such as political ideology.

Some of the specific psychological variables that are useful for explaining acceptance of or resistance to change are listed below. This is by no means a complete list, but is useful for identifying some of the more important personality factors associated with individuals and their general approach to change and innovation.

o **Sense of competence** - This factor may be defined as the individual's perception of

what he or she can and cannot do, based upon the person's history of behavior and accomplishment. The importance of this variable for this context is that it may be a predictor of the future behavior of individuals with respect to adoption of innovation. Those having faith in their abilities to perform tend to seek out more and different things to accomplish in their environments, including the trial of innovations and new technologies. Objects and practices that are perceived to be not within one's area of competence are more likely to be rejected, especially if the perceived area of competence is small (Havelock, 1979).

o **Persuasibility** - This general factor is an indicator of an individual's tendency to be affected by deliberate influences. Persuasibility is affected by factors such as imagery and empathy, "other-directedness" orientations, social extroversion, and a lack of overt hostility. Persons exhibiting this factor to high degrees may be more prone to adopt or reject an innovation (Janis, 1963).

o **Authoritarianism** - The most global of indicators is the authoritarian personality (Adorno et al., 1950). Originally, the studies that were performed on authoritarianism were directed at specific ethnic groups that were believed to be culturally oriented toward rigidity and control. Later studies showed that all cultures can and do foster the development of individuals exhibiting traits such as prejudice, intolerance of ambiguity, rigidity, political and economic conservatism, overconcern with status and success, and a strong sense of submission to authority. Such individuals, according to the researchers, are "natural" resisters of change, preferring to move slowly and cautiously when confronted with new ideas. Later research by Rokeach (1960) attempted to show that authoritarianism is not extreme political beliefs, and thus should rightly be regarded as **dogmatism** instead. The implication of these studies is that, to the extent that these personality traits exist and are demonstrated by individuals, more resistance to change would be expected.

Although factors and traits like those described above may be important for understanding some of the dynamics of humans, they shed little light on how we may intentionally change such conditions to favorably impact adoption of innovations. The burden of promoting change will continue to be on creating good, useful innovations and practices, emphasizing the best utilization attributes in the design and development of the innovation, and following up on the use after adoption. This last category of adoption variables - what happens after the decision to adopt or accept the innovation - will be the topic of the next section.

<u>Behavior Attributes and Consequences of Innovations</u>

In many, if not most organizations, there may be a difference between the adopting group and the user group. In educational and training organizations, for example, administrators and managers may decide to adopt an innovation or technological practice that is to be used by teachers or instructors. The organizational environment is therefore ripe with opportunities for resistance, since the decision is often made without the input of users. The two major categories of adoption/rejection of innovations during this stage are 1) **implementation** (use) of the innovation and 2) **consequences** of the use.

Immediately after the adoption decision is made, provisions are typically made for the implementation of the innovation. Fullan and Pomfret (1977) have made an extensive review of literature pertaining to the implementation of educational innovations, especially those that are curriculum innovations. Although user training was found to be linked to greater rates of use, intensive in-service training was found to be the most effective means of ensuring continued use and acceptance. Contrast this approach with pre-service or workshop types of training, in which instructors receive cursory instruction or familiarization with the materials or devices. In-service training was found to be more effective due to 1) the provision of detailed demonstrations, 2) the provision of reinforcing experiences in hands-on situations with the materials, and 3) an opportunity for instructors to be "resocialized" in the new ways of the innovation's use. The addition of elements such as these (i.e., beyond training materials alone) is responsible for the kind of increased learning and performance exhibited by the teachers and instructors studied by Fullan and Pomfret (see Matthews and Fawcett, 1977 and Fawcett and Fletcher, 1977 for additional examples of how intensive training makes innovation use more resistant to extinction).

The implementation issue is really a two sided one. If an innovation has been field-tested and validated for use among its intended population, it should, in theory, be used exactly the way it is designed and in the manner in which users are trained. However, as noted earlier, one of the attributes of "good" innovations is that they be adaptable to the needs of the user. This means that users will change the use regimen to suit their own specific purposes. Therefore, the innovation comes to be used in a manner different from its intended use. At the risk of seeming evasive, it must be noted that the answer lies with both positions. Good innovations must be designed and developed with user input and must be user-friendly; they must also be designed to be adaptable to the growing needs of user groups as

necessary. This approach can be seen in the formal Levels of Use identified by Hall et al. (1975) and described earlier, in which users may ultimately refine and change the innovation according to their needs.

The best illustration of the two sided nature of innovation use can be seen with the military's use of the Instructional Systems Development (ISD) model. Since the formal development and implementation of this approach among the various branches of the services in the mid 1970s, the model has been used and subsequently both hailed as the saving grace of systematic training and decried as a terribly expensive, time-consuming method that yields results indistinguishable from older instructional methods. Branson, one of the authors of the Interservice Instructional Systems Development model, has noted that the system can be used as written with great success; however, the model can also be adapted to the particular constraints of users without fear that such adaptations will invalidate anything created using the model. The ISD model was developed to provide courseware developers with sets of guidelines for curriculum development, not a Bible that must be followed in an orthodox manner. In fact, since the original Interservices ISD model was developed, there have been several changes, additions, and collateral documents created that provide additional guidance (e.g., the Training System for Maintenance - TRANSFORM - developed by the Air Force's 3306th Test and Evaluation Squadron). The most useful innovations are those that work when used as designed, but also allow for adaptations (R. K. Branson, personal communication, December 1, 1988).

One of the major failings of research in the area of innovation adoption and use is the limitation of studies only to the **process** of adoption rather than continuing the investigation to include what happens **after** the innovation has been adopted. Such studies have made the rate of adoption the critical dependent variable, rather than a more inclusive set of variables related to the consequences of adoption and use. The consequences of use of new materials and practices are perhaps more difficult to measure and may not be of interest to some researchers; nonetheless, the impact may be significant especially to individuals. The problem for individuals is that there are rarely any rewards for them to use or develop innovations. The best description of what is at stake is provided by Beales (1968, and cited in Kaufman, 1970):

"Technicians and planners often seem both surprised and distressed when resistances are encountered to innovations of obvious merit - obvious, at least, in the eyes of the innovators. Yet in fact resistance to change is

normally to be expected at some point from some members of the receiving society. Even minor technological innovations not only may introduce new means to achieve established ends but may create new goals. In addition to requiring the establishment of new work habits, technological change involves some restructuring of social relationships. A relatively slight change may mean the obsolescence of one valued skill which gave status or economic security. More extended changes may destroy whole security systems for part of a population, alter relative statuses and economic positions, and redistribute power and leadership. All individuals and groups who perceive change to be to their disadvantage in any way will be resistant to them unless compensating advantages are presented or evident. Even to admit the superiority of the knowledge of another may involve intolerable loss of prestige or self-esteem in some societies. The technological innovation which sooner or later arouses no resistance must be extremely trivial." (Emphasis added, p. 170).

Example Studies Two studies are provided that demonstrate the relevance of the variables described herein. The first study is from the Florida educational system, and shows the importance of some of the adoption and use factors as perceived by user groups. The second example is from the military training establishment and shows the results of a review of variables associated with the success and failure of self-paced learning courses in the Air Force.

Richardson and Papagiannis (Note 1) reported findings of a study of nine facilitating conditions of innovation use as perceived by teachers and administrators in 23 Florida schools. Table 1 shows the results of ratings of importance of the conditions. It should be noted that the two most important conditions as perceived by the sample of educators were organizational support and individual motivational factors. The rest of the list and their associated ratings indicate that proper training and user input, along with active change agents, are necessary ingredients in the innovation adoption and use process. (see Table 1)

The second study is provided by McCombs, Back, and West (1984) and provides an indication of the importance of utilization variables in the design, development and use of self-paced instructional materials. The authors reviewed the use of 12 self-paced courses at four Air Force technical training bases to identify the factors associated with successful use or failure and discontinuance. Table 2 presents the list of factors resulting from the study. Motivation of the instructors, instructor training, organizational support, participatory development and management, and flexibility of

implementation were all noted as important variables in the study. Importantly, the kinds of innovation attributes cited by Burkman (1987) also received support: importance of student-instructor interactions, costs of and need for additional equipment, and quality of student materials were cited as factors determining success or failure.

The two studies cited above indicate that the kinds of variables identified in studies of innovation adoption and use (and described in this paper) are found in specific educational and training settings in both the civilian and military sectors. The majority of innovation that occurs in civilian settings, however, is curriculum-based, and (with the exception of computer-based instruction) may not reflect high levels of technology such as those found in the equipment used in military settings. The McCombs, Back and West study also focused on instructional materials as the source of innovation. Do the same issues apply to settings in which innovation is predominately technological and oriented toward computers and electronics?

Stoffer, Blaiwes, and Brictson (1981) suggest that the answer to this question is yes. In a review of the problems associated with user acceptance of research and development studies and training devices in the Navy, the authors list a number of issues that are common to the variables described above. They are presented below:

- **Deficiencies in user motivational conditions** - these include lack of rewards or incentives for users, increased workload, and poor relations with R & D groups.

- **Deficiencies in user role assignments** - this relates to the differences in culture and methods associated with user and R & D groups concerning issues such as cost of the study, need for the study, failure to maintain proper liaison before and during the study, etc.

- **Deficiencies in official organizational policy and structure** - this includes the implementation of "non-interference" policies that can make R & D more difficult, instructor rotation/turnover, lack of instructor training, and lack of R & D support.

- **Inadequate defense R & D contracting methods** - there is no formal recognition of user acceptance as a problem to be addressed.

- **Failure to include users in the acquisition process** - there is a lack of participative management, thus reducing the user's sense of ownership in the process of design, development, and use.

- **Other-than-rational user responses to R & D** - expressions of resistance to R & D studies due to perceived lack of applicability to the user's setting, complexity of setting, lack of credibility

of researchers, and inadequacy of training devices.

o **Deficiencies in the training device design** - inadequate design of student station (usually associated with lack of physical fidelity), or lack of appropriate instructional features.

The review of factors associated with user rejection of R & D and training devices suggests that there is considerable overlap between the types of variables listed as causes of user rejection (or acceptance) in both high technology and low technology settings. In their conceptualization of the user acceptance process, Stoffer, Blaiwes, and Brictson have developed a model that reflects the critical issues, stages of change, and kinds of change to be achieved. This model is presented in Figure 2. Their conceptualization is useful for showing the inter-relationships of the degree of change, its desired permanence, and the kinds or levels of change desired. The categories of the kinds of change desired are derived from Hersey and Blanchard (1977), and provide a roughly parallel approach to the stages of the various models presented in Figure 1. In the Hersey and Blanchard approach, change is perceived as more difficult to achieve but becomes more permanent as it is incorporated as a part of the behavior of individuals and groups. There is also an attempt to group the kinds of change with the stages of change and the critical issues associated with completing a study or accomplishing the desired change (note use of vertical dotted lines to indicate commonalities).

Summary and Conclusions This review of innovation adoption and use has provided general variables related to the change process and specific variables that are related to education and training settings. These variables were presented using a stimulus-organism-response-consequence (S-O-R-x) paradigm as the organizing model for grouping and presenting the results of the studies. There is consensus that the results of studies on innovation and change across disciplines are generalizable to educational and training settings.

The question that must be answered, however, is why innovation adoption and use remains a problem when so much is known about the causes of user rejection and discontinuance of use. The answers are probably varied, ranging from lack of awareness of the issues on the part of developers and researchers, to lack of resources for ensuring successful adoption and use, to outright apathy. For those organizations willing to assist the innovation use process, the results of studies such as this one should be used to generate a formal, validated method of planning for change. The first step in such a process is the identification of the possible variables involved in

the adoption and use process, which is accomplished through papers and studies such as this one. These results can be provided to planners in the form of "issues to be addressed" until such formal processes for planning are developed and tested. Figure 3 shows the kinds of questions that should be addressed when planning for the implementation of some innovation or technology, having been derived from the variables identified by this review.

In addition to the use of planning issues shown in Figure 3, there are additional ways in which we can help to ensure minimal resistance to innovations:

1) **Develop an objective methodology for categorizing and evaluating innovations -** Both Downs and Mohr (1976) and Burkman (Note 2) have suggested that the worth of new technologies and instructional innovations must be determined by a more objective means of categorizing innovation characteristics and by more objective and thorough evaluations of the effectiveness of the process or product that comprises the innovation.

2) **Document the need for the innovation and ensure that it is a viable solution to a documented problem** - Many of the instances of user rejection of innovations concerned the quality of the innovation, and its ability to be used effectively in the intended setting with the targeted group. The first law of applied R & D or instructional development should be that the product meet an identified need.

3) **Provide incentives and support as part of the organizational commitment to innovation to ensure that users are not punished for valuing change and innovation** - In schools and school systems this effort may only be possible through massive restructuring of the system, which makes this method unlikely.

4) **Provide training to all users of the innovation throughout the life cycle of the innovation** - This will ensure that the product or method is implemented correctly and will provide the intended results.

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<table>
<tr><td>MODEL OR PARADIGM</td><td colspan="10">ELEMENTS</td></tr>
<tr><td>LEARNING/ BEHAVIOR (S-O-R-X)</td><td></td><td colspan="3">STIMULUS</td><td>ORGANISM</td><td colspan="2">RESPONSE</td><td colspan="3">CONSEQUENCE</td></tr>
<tr><td>COMMUNICATION (S-C-M-R-E)</td><td></td><td>SENDER</td><td>CHANNEL</td><td>MESSAGE</td><td>RECEIVER</td><td colspan="2">*</td><td colspan="3">EFFECT</td></tr>
<tr><td>INNOVATION ADOPTION (ROGERS & SHOEMAKER, 1971)</td><td></td><td>KNOWLEDGE</td><td colspan="2">PERSUASION</td><td>DECISION</td><td colspan="2">**</td><td colspan="3">CONFIRMATION</td></tr>
<tr><td>STAGES OF CONCERN (HALL & LOUCKS, 1978)</td><td>AWARENESS</td><td colspan="3">INFORMATIONAL</td><td>PERSONAL</td><td colspan="2">MANAGEMENT</td><td>CONSEQUENCE</td><td>COLLABORATION</td><td>REFOCUSING</td></tr>
<tr><td>LEVELS OF USE (HALL, et. al. 1975)</td><td>NON-USE</td><td colspan="3">ORIENTATION</td><td>PREPARATION</td><td>MECHANICAL</td><td>ROUTINE</td><td>REFINEMENT</td><td>INTEGRATION</td><td>RENEWAL</td></tr>
</table>

* "RECEIVER" also fits within this group

** "DECISION" also fits within this group

Figure 1: A comparison of models of communication and change. Areas of commonality are shown as grouped elements

CONDITION	IMPORTANCE*	RANK
Administrative support of the change process	5.462	1
Faculty motivation toward school improvement efforts	5.393	2
Inservice training efforts	5.216	3
Participatory decision making	5.148	4
Linkage agents	5.080	5
Internal advocacy groups	5.019	6
Technical assistance during the change effort	4.959	7
Outside resources	4.942	8
Information on R&D products	4.874	9

* Based on a six point scale

Note: The table is partially reproduced from Richardson and Papagiannis

Table 1: Rank and Mean Importance of Nine Facilitating Conditions as Perceived by Users of Educational Innovations in 23 Florida Schools

	Success Factors		Nonsuccess Factors
1.	High Instructor Dedication/ Motivation Toward Self-Paced Instruction	1.	Low Instructor Dedication/Motivation Toward Self-Paced Instruction
		2.	Lack of Deliberate Efforts to Keep Instructor Motivation High
		3.	No Well-Defined Instructor Roles
		4.	Lack of instructor Role Training
2.	Flexible Implementation Approach	5.	Inflexible Implementation Approach
		6	Inflexible Use of 8-Hour Training Day
3.	Effective Scheduling of Limited Equipment	7.	Ineffective Scheduling of Limited Equipment
4.	Adequate Opportunity for Student/Instructor Interactions	8.	Inadequate Opportunity for Student/ Instructor Interactions
5.	Incorporation of Team and Group Activities	9.	Lack of Incorporation of Team and Group Activities
6.	Low Requirements for Actual Equipment	10.	High requirements for Large, Expensive Equipment
7.	Staff Involvement/Participatory Management	11.	Lack of Staff Involvement/ Participatory Management
		12.	Lack of Strong Management Support
8.	Quality Instructional Material	13.	Low Quality Instructional Material
9.	Method Matched to Knowledge/ Performance Requirements	14.	Lack of Multilevel Staff Orientation/ Training
10.	Method Matched to Field Requirements	15.	High Emphasis on Completion Time
11.	Method Considered Cost effective	16.	Low Student reading Ability
		17.	Low Student Motivation
		18.	Low Student Maturity

Table 2: Factors Consistently Related to Success or Nonsuccess of Self-Pacing (McCombs, Back and West, 1984)

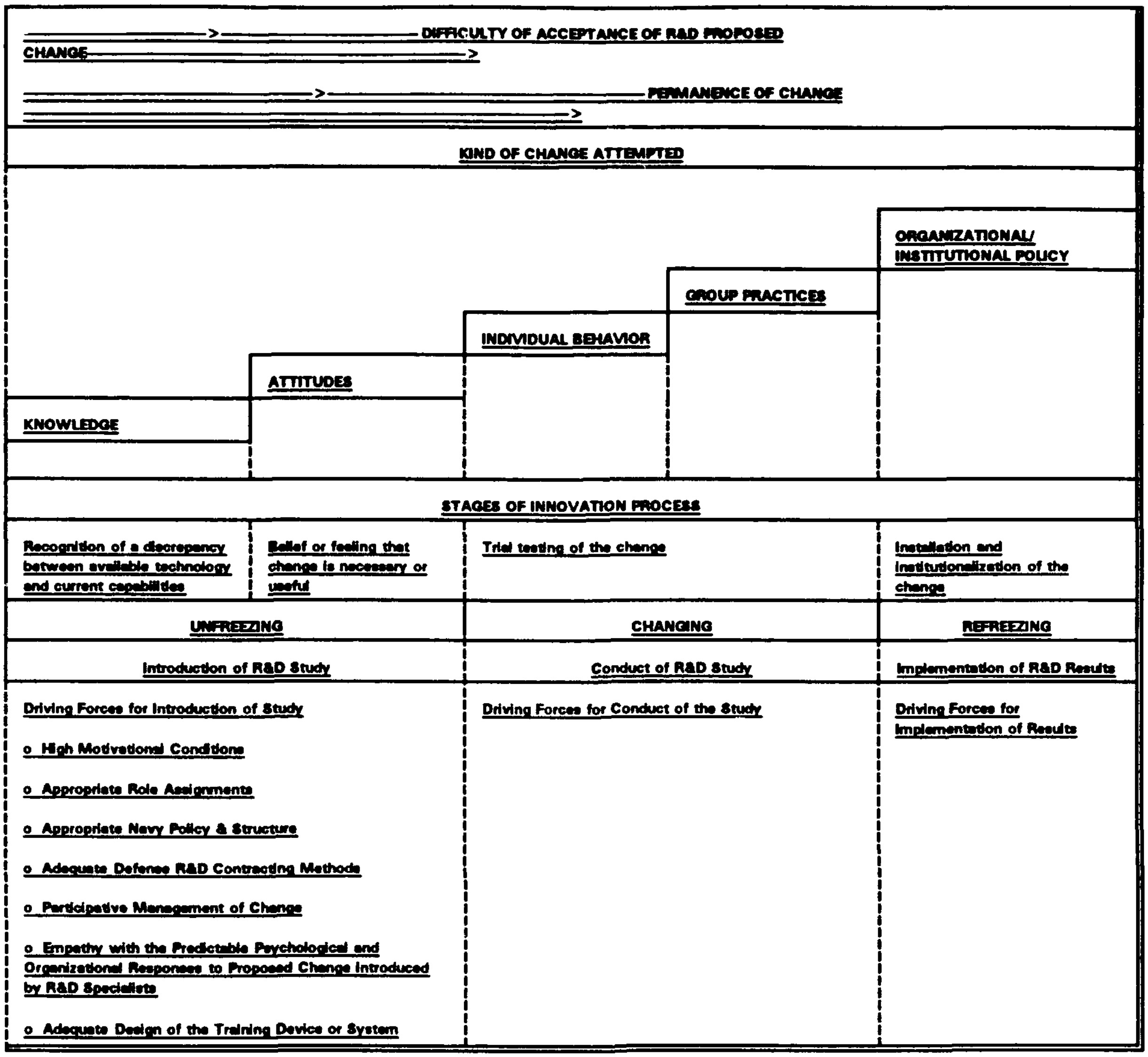

Figure 2: Stoffer, Blaiwes, and Bricteon's model of the acceptance process (1981).

Innovation Stimulus Characteristics	Organizational/Individual Characteristics of Users	Innovation Implementation and its Consequences
How do users perceive the attributes of the innovation (i.e., relative advantage, compatibility, complexity, trialability, observability)?	What are the characteristics of the organization utilizing the change process (e.g., public vs. private, large vs. small)?	Is the innovation useful and effective when used?
Are there more objective appraisals of the innovation's characteristics?	What are the organizational barriers to change?	Is the innovation implemented correctly?
Is the innovation tangible or intangible?	Are there cultural barriers to the proposed change (e.g., "culture gaps")?	Are there negative (personal or organizational) consequences of the use of this innovation?
What types of change agents are involved in the change process?	Are there social/group barriers to the proposed change?	Are there any incentives for users to adopt the innovation or change current behaviors?
Do change agents demonstrate the appropriate change-related skills, knowledge and attitudes?	What are the identifiable characteristics of individuals who will use the change or innovation?	Do innovation users receive proper training in the innovation's use?
Are there internal as well as external change agents?	Are users involved in the decision to adopt or modify the change?	Do users have the opportunity to suggest or make necessary changes in the innovation based on actual use?
Do the users of the change or innovation have input to the development process?	What are the attitudes of users toward this and other change efforts?	Are critiquers charged with making useful suggestions for alternatives?

Figure 3: A matrix of dimensions and associated issues involved in the adoption and use process

TRAINING FACILITY NETWORK ASSESSMENT USING TRAFFIC MODELS

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Abstract

The proposed Space Station Training Facility (SSTF) at the NASA Johnson Space Center will contain several simulators, Instructor/Operator Stations (IOSs), and other equipment. Different architectures have been suggested for the SSTF and are to be evaluated. A single Local Area Network (LAN) has been proposed for inter-connecting the simulation hosts and all the IOSs. Models were developed to simulate the data traffic anticipated on the network due to both the cyclic and the stochastic interaction between the hosts and the IOSs. The performance of different LANs, including Starlan®, Ethernet®, IEEE 802.5 token ring and Fiber Distributed Data Interface (FDDI) was assessed under a variety of conditions using the models. Besides studying normal traffic, capability for handling burst traffic was evaluated. The study showed that Ethernet, token ring and FDDI would meet the requirements but they differed in their potential for accommodating growth in the number of IOSs.

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TRAINING FACILITY NETWORK ASSESSMENT USING TRAFFIC MODELS

Daniel T. Wick and Ankur R. Hajare

INTRODUCTION

As a part of the Space Station *Freedom* Program, a new training facility, called the Space Station Training Facility (SSTF), is to be built at the NASA Johnson Space Center (JSC) at Houston, Texas. The SSTF is in the planning stages and alternate architectures are being evaluated. Commonality with existing and proposed NASA systems, and the use of commercial-off-the-shelf products are driving forces in selecting among alternate design choices. The methods being used to study the various alternatives include discrete event simulation and analytic modelling. One of the studies performed was an investigation of the feasibility of a commercial-off-the-shelf Local Area Network (LAN) for all the Instructor/Oper-ator Stations (IOSs) witnin the SSTF

There are at least four valid reasons for networking all the IOSs instead of the direct point-to-point connections that have been used in the past in training facilities such as the Shuttle Mission Training Facility. First of all, networking the IOSs permits interchangeability, i.e., any IOS can be used with any host computer. In the Shuttle Mission Training Facility this was achieved by means of a switch for the two Shuttle Mission Simulator (SMS) bases and the two host computers[1]. In the SSTF, where at least five simulators and 13 IOSs are presently under consideration, a switch becomes an expensive and cumbersome solution. A second reason for utilizing a network approach is that it supports growth. New IOSs and hosts can be added easily to a network, whereas such additions are much more complex with a switching arrangement. This is important for the SSTF because the number of trainers will probably change during the projected long life span of Space Station *Freedom*.

A third significant advantage in utilizing a network solution is that a training session with multiple IOSs can be configured easily on a network. The concept of operations document for the SSTF[2] calls for combined training sessions which may have multiple IOSs. With a network, any subset of the available IOSs can be assigned easily to any combination of simulators. Finally, a network solution supports message broadcasting to all IOSs. Though numerous direct point-to-point connections could be used, the simplest approach to the broadcasting requirement is an IOS network.

MODELLING TOOLS

Two modelling tools were used for this study. Both of them build discrete event simulation models. The first tool was the Performance Analysts Workbench System® (PAWS®), marketed by Scientific and Engineering Software of Austin, Texas. Version 3.0 of PAWS was used on a Digital Equipment Corporation VAX 11/750.

The second tool used for the study was Network II.5® which is marketed by CACI Products, Inc. of La Jolla, California. Version 4.0 of Network II.5 was used on a IBM *PS/2 Model 80*. *Network II.5 contains* built-in models for transfer devices that use collision, token ring and other protocols. A specific LAN is, therefore, modelled by an appropriate selection of parameters.

IOS NETWORK MODELS

Models were developed for Ethernet, Starlan, token ring, and Fiber Distributed Data Interface (FDDI) LANs. All of them are described by Stallings[3]. For each protocol several models were built in order to assess the performance under various conditions. Initially, a Localtalk® LAN was also modelled. However, it was soon discarded because Localtalk has a data rate well below the expected load.

The statistics collected for each model included LAN utilization, queue lengths, and the minimum, maximum and the average of the message transfer times.

Basic Configuration

Since the SSTF is still in the planning stages, the system architecture has not been finalized. Various candidate architectures have been proposed and one of them was selected for modelling. It consists of five host computers and 13 IOSs, as shown in Figure 1.

The traffic on the network was estimated on the basis of the preliminary versions of the conceptual design and the concept of operations of the SSTF[2]. In the model, IOSs send two types of messages to a host computer: (1) commands, and (2) requests for a download, e.g. a new page. These messages were assumed to be 80 bytes long and 40 bytes long, respectively, on the average. Commands were generated with a Poisson distribution with a mean of 1 minute. Requests for a download were also generated with a Poisson distribution, but with a mean of 10 minutes.

Each IOS receives a message from a host once a second to update information in its display pages. It was assumed that 10 display pages would be updated and each one would contain 100 double precision variables. The message length for this was estimated at 72 Kb, which would include numeric values as well as the variable text on a page.

Commands from the IOS to the host do not cause any additional data traffic. Instead, they cause changes in the data that is contained in the periodic updates. When an IOS requests a download, a host responds by sending 144 Kb of data. The download has a lower priority than the periodic update but cannot be preempted once it has started.

The data traffic used for the model is intentionally higher than would be expected in a typical scenario. The numbers were chosen in order to add a factor of safety to the results obtained from the model. However, the data rate derived above is still considerably less than the data rate between the IOS and the host computer of the SMS. Measurements on the SMS(1) indicated a traffic rate 750 Kb/second to the IOS. The difference between the SMS data rate and the lower rate anticipated in the SSTF can be explained on the basis of architectural differences ensuing from technological advances since the design of the SMS in the mid-1970s. The IOS of the SMS contains alphanumeric and graphic terminals with little internal processing. The entire display is re-drawn during an update. The IOSs in the SSTF, on the other hand, will be workstation based. Page formats will either be stored at the workstation or will be downloaded to it from the host. The entire display will not have to be re-drawn every second. Only the information needed to update the displays will be sent to the IOSs.

At the beginning of a training session there may be file transfers from the host to the IOSs in addition to many requests for a download. This was not simulated because these would be accomplished before the real-time simulation began and would, therefore, not impact real-time operation.

Ethernet Model

Ethernet is a Carrier Sense Multiple Access/Collision Detect LAN running at a speed of 10 Mb/second. Stations wishing to transmit listen for a signal and transmit only when they sense that the LAN is idle. If more than one station starts transmitting, a collision is detected and transmission is aborted. The stations attempt to transmit again after a random interval, using a binary exponential back-off algorithm.

Ethernet was modelled with a fixed size collision window, although in reality it is a function of the distance between the nodes that are attempting simultaneous transmission. In order to study the performance under different conditions, the model was run with various parameter settings. The frame size on an Ethernet can vary from a minimum of 46 bytes of data per frame to a maximum of 1500 bytes of data per frame. The two extremes were modelled. The collision window on an Ethernet depends upon the length of the cable and upon the repeaters in the path. The maximum permissible collision window is 51.2 μs, which is the time for the smallest frame, i.e. 46 bytes of data

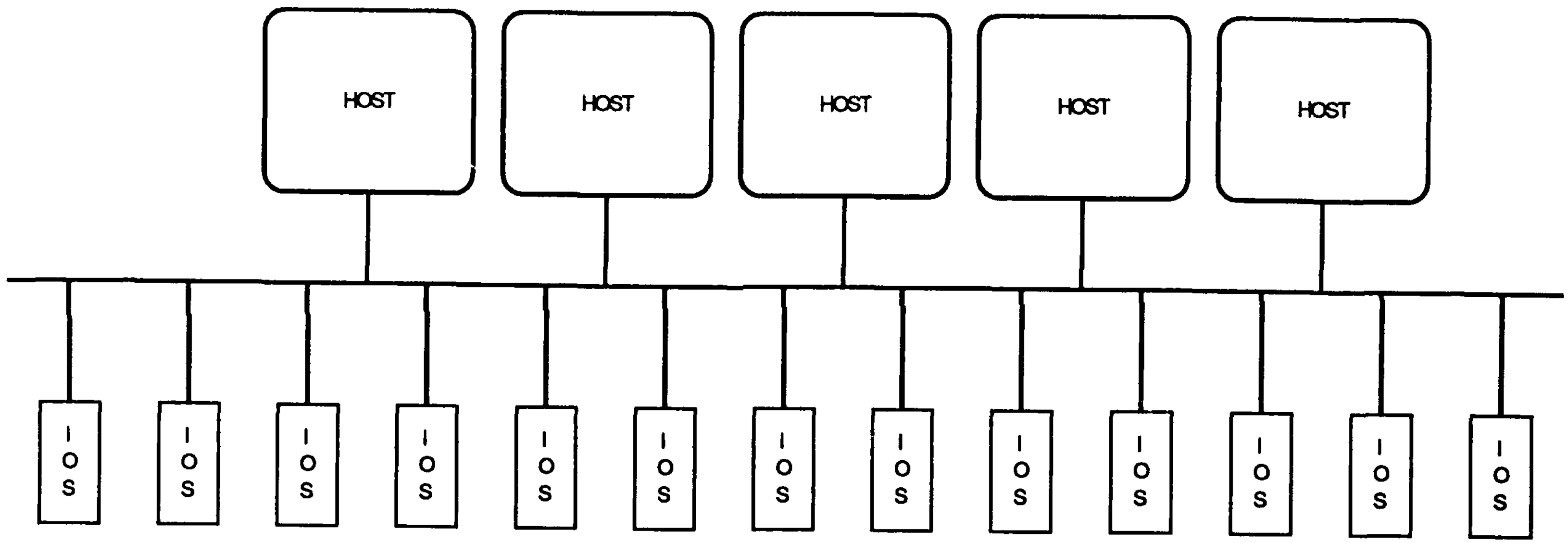

Figure 1
Modelled Configuration

plus 18 bytes of overhead. The model was run with a collision window of 51.2 μs and with a collision window of 2 μs, which corresponds to 650 feet of cable and no repeaters. This is reasonable for an IOS LAN within one building, as will be the case for SSTF.

The model was run for one hour of simulated time for each scenario. Initially, the model had update messages arriving at exactly one second intervals. Thus, all data for the once per second update was queued at one instant. The model was then modified to depict a more realistic scenario. This consists of the update messages arriving sometime within each second with a uniform probability distribution.

When the messages arrived with a uniform statistical distribution, the number of collisions decreased to a relatively small number. Since collisions contributed insignificantly to utilization, there was little change to the utilization of the LAN. The difference between uniform arrivals and instantaneous periodic arrivals was in the message transfer time. With a uniform arrival rate, the average message transfer time was only 8 ms, just slightly higher than the theoretical best. However, with instantaneous periodic arrivals it was 20 ms. The maximum was about the same for both cases because a statistically uniform arrival rate could create a situation as bad as simultaneous arrivals.

Starlan Model

Starlan is a Carrier Sense Multiple Access/Collision Detect LAN like Ethernet, but has a date rate of 1 Mb/second. The specifications for frame size and collision windows for Starlan are the same as for Ethernet, hence Starlan was modelled with the same frame sizes and collision windows as Ethernet.

Token Ring Model

All stations on a token ring LAN are connected in a ring. When the LAN is idle, a token circulates around the ring. A station that wishes to transmit must wait until it gets the token. It then holds the token until it has finished transmission.

The IEEE 802.5 standard[4] specifies two data rates, 1 Mb/second and 4 Mb/second. Therefore, both data rates were modelled even though the lower rate is not in widespread use. A higher rate that is commercially supported, 16 Mb/second, was not modelled because it was not a standard at the time of the study. The IEEE 802.5 standard does not directly specify a maximum frame size. However, the maximum time that a node can hold a token is 10 ms by default. For a 1 Mb/second token ring, the 10 ms time period translates to a frame size of 1125 bytes of data and the model was, therefore, run with that frame size. The IEEE 802.5 standard does not specify a minimum size for a frame. However, the model was run with a frame size of 46 bytes of data to afford a comparison with Ethernet.

For a 4 Mb/second token ring, the default limit of 10 ms on token holding time translates to a maximum frame size of 4500 bytes of data in a frame. The model was run with that maximum frame size and also with a frame size of 46 bytes for the sake of comparing it to Ethernet.

FDDI Model

The FDDI LAN is a 100 Mb/second LAN with a token ring protocol that is similar to IEEE 802.5. Data encoding in FDDI is different from IEEE 802.5, but this does not affect a performance model. Token passing is different and this was taken into account in the model. Anomalies are handled differently in FDDI and IEEE 802.5, but these special situations were not modelled. The maximum frame size for FDDI is 4500 bytes and this frame size was modelled. Also, a frame size of 46 bytes was modelled for a comparison with Ethernet.

RESULTS

The results of the model runs are presented here for the basic configuration, for burst traffic and for a growth scenario.

Basic Configuration

Under the best conditions (small collision window, large frames), the Ethernet LAN was only 9.5% busy. Collisions increased the utilizations by less than 0.01%. There were about 12 collisions per second during the simulation run but each one used the LAN for just a few μs. When the frame size was decreased to the minimum allowed by Ethernet, the frame overhead increased the LAN utilization to 13.4%. Once again, collisions affected this figure by less than 0.01%.

In order to assess performance under the worst conditions, the size of the collision window was increased to the maximum allowable for Ethernet. This roughly tripled the number of collisions and increased the utilization from 13.4% to 13.5%. The primary effect of the higher collision rate was not on utilization but on the message transfer time. The average message transfer time increased from 27 ms to 31 ms. However, the maximum message transfer time during a one hour run increased from 47 ms to 83 ms.

The model demonstrated that Starlan could not handle the traffic under any conditions. As the simulation progressed, message queues kept on increasing, demonstrating the inability of the LAN to handle the offered load. The same condition was encountered with the 1 Mb/second token ring model, demonstrating that it, too, was not capable of handling the traffic.

The 4 Mb/second token ring model demonstrated that this LAN was capable of handling the workload. This LAN was 34.7% busy with short frames, and the maximum message transfer time was 105 ms. With the maximum size frames, the LAN was 23.9% busy, and the maximum message transfer time was 73 ms.

The FDDI model showed that this LAN was only 1.7% busy with short frames. With the maximum size frames, the LAN was only 1.0% busy. The maximum message transfer time was only about 10 ms.

Burst Traffic

The ability of the different types of LANs to handle burst traffic was studied by simulating an instantaneous burst of 100 messages of 72 Kb each. The time to recover from the burst was compared for the different types of LANs. As might be expected, FDDI was the fastest to recover from the burst, taking only 0.1 seconds to do so. Ethernet required 1 second to recover from the burst and a 4 Mb/second token ring took 3 seconds.

Growth Capacity

The capacity for growth for each LAN was studied by adding IOSs until the saturation point was reached, indicated by message queues increasing in length as the simulation progressed. Thus, the maximum number of IOSs that the LAN could support was derived. Since this was done for various combinations of parameters, a significant number of model runs was required to determine the breaking point for each case.

As the network load increased, Ethernet showed the maximum transaction time increasing rapidly, even though the average did not increase much. This was because a few transactions suffered many collisions. Under the best conditions, Ethernet could support 115 IOSs. However, when the collision window was increased from 2 μs to 51.2μs, the maximum number of IOSs dropped to 35. Clearly, under a heavy load, the size of the collision window has a significant effect. Changing the frame size from the 1500 byte maximum to the 46 byte minimum did not have that much of an effect. The maximum number of IOSs dropped to 25 when the frame size was reduced to the minimum.

For Starlan, the limits to acceptable performance were studied by lowering the number of IOSs until the LAN could handle the load. Under the best conditions it could handle 12 IOSs. When the collisions window was increased to the maximum, it could only handle 10 IOSs. Under the worst conditions Starlan could handle only 6 IOSs.

To determine the limit for a 1 Mb/second token ring, the number of IOSs was reduced, as with Starlan. With long frames (i.e. 1125 bytes of data), a 1 Mb/second token ring could handle 12 IOSs. However, with a frame size of 46 bytes of data, it could handle only 9 IOSs.

The growth capacity of a 4 Mb/second token ring was investigated by increasing the number of IOSs in the model, as with Ethernet. With long frames, a 4 Mb/second token ring could support 49 IOSs, whereas with short frames the maximum number was 32.

In the case of FDDI number of IOSs was increased to 200 and there were no performance problems. Since this is far more than the number of IOSs that the SSTF will ever have, there appeared to be no practical reason for expending further effort to determine the limit at which an FDDI LAN would be saturated.

The growth capacity for the four LANs studied is listed in Table 1.

CONCLUSIONS

The models demonstrated that Starlan and the 1 Mb/second token ring would not handle the traffic anticipated on the IOS LAN in the SSTF. However, Ethernet, the 4 Mb/second token ring and FDDI were capable of handling the traffic. All three offered growth potential well beyond the requirements anticipated today.

LAN	Number of IOSs	
	minimum	maximum
Ethernet	25	115
Starlan	6	10
1 Mb Token Ring	9	12
4 Mb Token Ring	32	49
FDDI	> 200	> 200

Table 1: IOS LAN Capacity

ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS

FDDI	Fiber Distributed Data Interface
IBM	International Business Machines
IEEE	Institute of Electrical and Electronic Engineers
IOS	Instructor/Operator Station
JSC	(Lyndon B.) Johnson Space Center
LAN	Local Area Network
Kb	Kilobits
Mb	Megabits
ms	milliseconds
μs	microseconds
NASA	National Aeronautics and Space Administration
PAWS	Programmer Analysts Workbench System
SMS	Shuttle Mission Simulator
SSTF	Space Station Training Facility

KEY WORDS

Space Station Training Facility
Instructor/Operator Station Network
network simulation
network traffic models
network performance assessment

A Training Facility for Space Station Astronauts

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Abstract

The Space Station Training Facility (SSTF) will be the primary facility for training the Space Station Freedom astronauts and the Space Station Control Center (SSCC) ground support personnel. Conceptually, the SSTF will consist of two parts: a Student Environment and a Author Environment. The Student Environment will contain trainers, instructor stations, computers and other equipment necessary for training. The Author Environment will contain the systems that will be used to manage, develop, integrate, test and verify, operate and maintain the equipment and software in the Student Environment.

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A Training Facility for Space Station Astronauts

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INTRODUCTION

The Space Station Training Facility (SSTF) will be located at the Lyndon B. Johnson Space Center (JSC) in Houston, Texas. The SSTF will support training of Space Station astronauts, Space Station Control Center (SSCC) ground support personnel, and Station customers throughout the life of the Space Station Freedom Program (SSFP).

The primary objectives of the SSTF are to provide astronauts and ground support personnel with the generic training necessary to allow operation of the Station systems and to provide Station configuration-specific training. SSTF training is conducted in both normal and contingency operations. The generic and configuration-specific training requirements of the SSTF are summarized in the SSTF requirements document [1].

Fundamental to the training philosophy for the SSFP is a commitment to attain commonality across the training media, the curriculum, and the training facilities. In all instances, this commonality will have to be maintained through intensive coordination between the centers developing the Station, supporting NASA centers, the international partners, the scientific community, and the academic community.

The SSTF is conceptually divided into the Author Environment and Student Environment [2], both of which may be supported by capabilities that are provided by the SSFP or by NASA institutional resources.

AUTHOR ENVIRONMENT

The role of the Author Environment is to support the management and operations of the SSTF and to support the development of the hardware and software components of training loads used in the Student Environment. The Author Environment contains the systems necessary to manage the facility; to develop, integrate, test and verify training loads; and to develop, reconfigure, maintain, and operate the hardware and software used in both environments of the SSTF. Primary goals of the Author Environment are to ensure the quality of the training loads used in the Student Environment and to verify the quality and fidelity of the systems used in both the Author Environment and the Student Environment.

The Author Environment systems will address all phases of the training load development life-cycle from design through final acceptance testing. The systems will provide support for activities such as reliability testing and the demonstration of human factors design principles. Reliability and availability requirements will be verified by analysis and special tests such as verification of redundant components, examination of operations trend data, and the use of built-in test equipment where practical.

The Author Environment systems will be used to perform audits of software quality attributes, such as correctness and completeness, and to collect the data required to measure hardware, software, system, and subsystem reliability and availability attributes. Quality assurance and commonality audits will be conducted throughout the development process. These audits will collect and organize the evaluation data at various periods during the requirements definition and product design phases. Analysis of the data, collected throughout the life-cycle of the SSTF, will verify that the objectives are being met.

The Author Environment will contain the following systems. Each system will include hardware, software, and procedures which may be shared with other systems.

- o Development
- o Reconfiguration
- o Operations and Maintenance
- o Test and Verification
- o Management Information Center
- o Product Consolidation and Distribution
- o Visual Scene Generation

Development. Development produces new or modified SSTF capabilities for both the Author Environment and the Student Environment. All SSTF systems ranging from the real-time simulation to institutional processes are eligible candidates for Development attention.

A Software Support Environment (SSE) is presently being built to support the development of all operational SSFP software. This SSE will provide an Ada Programming Support Environment (APSE) including software life-cycle tools, rules, and standards, and a Common APSE Interface Set (CAIS) for the SSTF computer hardware. The SSE will be implemented on multiple facilities, called Software Production Facilities, one of which will serve as the Development System of the SSTF.

Creation of new SSTF systems and/or subsystems may also require hardware or procedures design and development. These activities are the responsibility of Development and may be conducted at the SSTF or at other facilities.

Development will support the SSTF goals of high productivity, low life-cycle cost, reliability, maintainability, and operability. Development will also support the SSFP objectives of Automated Systems and Artificial Intelligence advancement.

The following activities must be supported by Development:

- o Coordination of all simulation and training requirements from all the SSFP participants.
- o Providing all support required for the Simulation Facility Director.
- o Providing assistance with problem diagnosis and repair for both hardware and software problems.
- o SSTF planning and scheduling.

The users of the Author Environment require the full spectrum of software development capabilities afforded by the SPF. Development users require, at a minimum, the capabilities to edit copies of existing source code, create new source code, compile source code, debug the code, and eventually execute the code in a training-like system separated from the Student Environment. The users will also require access to individual copies of all or parts of the SSTF training and simulations software to assist in the development and testing of new systems. This means that users require tools that allow the identification of the required software modules and the ability to transfer them among SSTF systems.

Development users require access to computer resources, configuration management information, and software development and testing tools. Furthermore, access to these various resources must be established via a common interface, thereby allowing all of a user's work to be performed from a single terminal or workstation.

Reconfiguration. Reconfiguration provides the capabilities necessary to integrate existing and newly-developed real-time software into Student Environment training loads to meet the changing Station configuration-specific requirements. The resulting training loads reflect new Station configuration-specific training scenario. As the Product Consolidation and Distribution archive of training load components increases in number, Reconfiguration provides the majority of the training loads from existing load components rather than from newly developed load components.

Because of the changing nature of the Station's configuration and its projected long life span, Reconfiguration will automate the assembly of training loads rather than using the historical method of custom designing and hand fitting of the software programs that comprise a training load.

Operations and Maintenance. Operations and Maintenance will comprise hardware, software, procedures, and user services that support the daily operations and problem identification, investigation, evaluation, and reporting for all of the SSTF.

Services provided by Operations and Maintenance include

- o Audit Trail of System(s) Usage
- o Collection of Training Effectiveness Data
- o Configuration Management
- o Hardware Maintenance
- o Hardware Modification
- o Libraries of Documents and Software
- o Securing Files
- o Training for Operations Personnel

In addition to these services, Operations and Maintenance will provide the following services specifically for the Author Environment:

- o Problem Incident Reports
- o Scheduling
- o Help Desk Staffing

Test and Verification. Test and Verification will contain test beds for the hardware and software that goes into the Student Environment and will contain hardware test equipment such as logic analyzers, and software quality assurance tools. Test and Verification has two major objectives: to ensure the ability of the subsystem elements to operate together as an integrated system and with other systems, and to evaluate system and subsystem performance and compliance with requirements.

Management Information Center. The Management Information Center will provide the ability to collect, collate, distribute, and archive all management information pertinent to the daily operations of the SSTF. It interfaces with other SSFP information centers for the efficient transfer of data between SSFP facilities. The Management Information Center will include the following capabilities:

- o Computer performance management
- o Configuration management
- o Data analysis and graphing
- o Discrepancy reporting
- o Electronic mail
- o Facility scheduling
- o Facility user identification
- o Logistics management
- o Organizational structure and directory information
- o Contractor task authorization
- o Simulation Facility Director's daily notes
- o Simulation task status information
- o Task authorization and tracking
- o Technical reports and product documentation
- o Test scenarios, results, and reports
- o Training records

Product Consolidation and Distribution. Product Consolidation and Distribution will be a software repository for all SSTF training module components. It will be used to support training load building and to archive software modules. Completed training loads modules, created by Development or constructed by Reconfiguration, will be archived here. All software modules stored in Product Consolidation and Distribution are under configuration control.

Visual Scene Generation. Visual Scene Generation will be used to develop and test visual scenes for use in the Student Environment. The data created by Visual Scene Generation will be archived in Product Consolidation and Distribution.

STUDENT ENVIRONMENT

The role of the Student Environment will be to support the presentation of training to SSFP students. The Student Environment contains the trainers that are used to train Station astronaut crew members, ground support personnel, and the JSC Training Division instructors for generic and Station configuration-specific activities. In addition to the trainers, the Student Environment contains support equipment and subsystems that are necessary for training operations.

The Student Environment uses hardware and software to perform simulations, and automated or manual procedures that guide the use of the software to accomplish the required training. The following objectives are used as the guidelines for designing and operating the Student Environment:

- o Satisfy evolving training needs and requirements.
- o Provide adequate training tasks and facilities.
- o Use effective training methodologies.

TRAINERS

The Student Environment will contain a variety of trainers which represent components of the Space Station. Figure 1 shows a proposed configuration of trainers in the SSTF. These trainers are described below.

Module Systems Trainer. The Module Systems Trainers (MSTs) will be used to train astronauts in operations performed at the Multi-Purpose Applications Consoles (MPACs) that will be on-board the Station [3]. There will be four MSTs in the SSTF corresponding to the four modules of the Space Station [4]: the Habitation (HAB) Module, the Laboratory (LAB) Module, the Japanese Experiment Module (JEM), and the European Space Agency (ESA) Module. The MSTs may be operated independently or in combination with other Student Environment training systems. The MST will support the following training:

- o Activity Planning
- o Communications Usage
- o Emergencies Simulation
- o Maintenance and Logistics
- o Nominal and Contingency Systems Management
- o Trajectory and Navigation Support
- o Use of Onboard Training Facilities

Station Proximity Operations Trainer. The Station Proximity Operations Trainer (SPOT) can be used as either an augmented MST or as a representation of the working environment of a Station node with an operable cupola represented by the visual system of the SPOT. The visual system surrounds the SPOT cupola and is used to present visual images necessary for the development of crew member skills requiring hand-to-eye coordination or precise control. The manipulative skills learned in the SPOT will be applied to the proximity operations that are accomplished from within the Station such as attached payload servicing, external Station systems maintenance, logistics module exchange, extravehicular activity (EVA) support, Orbital Maneuvering Vehicle berthing and release, and man-tended freeflyer berthing and release.

Node Systems Trainer. The Node Systems Trainer will be used to train crew members for tasks that are performed in the nodes of the Space Station, including tasks that require the use of an MPAC.

Ground Systems Trainer. The Ground Systems Trainer (GST) will be used to train Space Station Control Center (SSCC) ground support personnel in SSCC workstation activities. The training includes normal and emergency procedures required to support Station operations. The GST contains software, hardware controls, and displays that accurately reproduce both the function and appearance of the workstations located in the SSCC. Each GST has voice, command, and data communications with all Student Environment trainers.

Computer Assisted Instructional Trainer. The Computer Assisted Instructional Trainer (CAIT) provides single user, introductory or refresher training. The CAIT is not connected to the other trainers and does not participate in SSTF real-time training. The CAIT contains four student workstations connected to a dedicated lesson development, testing, storage, and distribution system. The CAIT is connected to a network for voice communications and for file transfer.

SUPPORTING SYSTEMS

A number of SSTF supporting systems will be located in the Student Environment to support the operation of the trainers and to interface the trainers to other SSFP systems.

Instructor Station. An Instructor Station (IS) will be used to monitor and control each trainer. Examples of monitor and control capabilities include mode control, malfunction insertion, and data retrieval. An

instructor will use these capabilities to conduct a training session; operations and maintenance engineers will use them to diagnose simulation failures; and training load developers will use them to integrate and test new simulation capabilities.

Each Instructor Station will have communications with other Instructor Stations, the SSTF trainer currently controlled by the Instructor Station, the SSCC, and the Mission Control Center. At a minimum, each Instructor Station will support the following capabilities:

- o Starting and terminating a training session
- o Control of the simulations and data logging and/or delogging
- o Support of external interfaces
- o Instructor-to-student communications
- o Malfunction insertion, removal and activation
- o Training report generation
- o Simulator performance monitoring via suitable graphics and/or alphanumeric displays

The Instructor Station also allows instructors to control the simulation with moding commands such as [5]:

- o Freeze
- o Run
- o Reset
- o Data store
- o Reconfiguration
- o Pre-Run
- o Step Ahead
- o Variable Time
- o Safe Store

Simulation Facility Director Console. The Simulation Facility Director (SFD) Console will allow monitoring and control of the daily operations of the SSTF. Any Instructor Station, when accessed with the proper sign-on codes, can be used as the SFD console. Normally, two Instructor Station units will be located in the designated SFD work area and will be dedicated for use as the SFD console. The SFD console has communications with all SSTF systems, the SSCC, the entire SSFP communication network, and NASA institutional systems.

The SFD will maintain active control of the Author Environment and the Student Environment, schedule access to SSTF facilities and systems, schedule maintenance personnel, prepare SSTF utilization reports, coordinate acceptance of development deliverables, coordinate reconfiguration, and assign change request or discrepancy report responsibility.

SSIS Network Simulator. The Space Station Information System (SSIS) Network Simulator (SNS) will model the SSIS ground segment [6] and will have the ability to interface the SSTF to the SSCC via the real world SSIS. The SNS will use the SSIS to connect SSTF trainers (except the CAIT) to SSFP facilities that are external to the SSTF (for example, the SSCC or the Payload Operations Integration Center). The SNS simulation models include the Data Interface Facility (DIF), the Tracking and Data Relay Satellite System (TDRSS), and portions of the SSIS that are located on Space Station Freedom.

In addition to uplink, downlink, multiplexer and demultiplexer simulation, the SNS will simulate the SSIS Tracking System, the SSIS Network Integration Management, and the SSIS Resource Scheduling System. Implicit in this is the necessity to simulate the TDRSS Network Systems and all SSIS and TDRSS protocols involved in transmitting, receiving, acknowledging, validating, and executing network commands.

TRAINING MODES

To support the wide variety of training requirements, the trainers in the SSTF (except for the CAIT) will operate in the following five modes [5].

Standalone. A standalone training session is one which utilizes a single trainer to accomplish the training objective(s).

Combined. A training session is classified as combined if any combination (two or more) of the SSTF trainers participate in a

third session (represented by the thin solid line) is a combined session consisting of a MST, the SNS and one GST. The fourth session (represented by the thick dotted line) is a combined session consisting of the SNS and the other GST. The fifth session is a standalone NST.

ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS

APSE	Ada Programming Support Environment
CAIS	Common APSE Interface Set
CAIT	Computer Assisted Instructional Trainer
DIF	Data Interface Facility
ESA	European Space Agency
EVA	Extra-Vehicular Activity
GSFC	Goddard Space Flight Center
GST	Ground Systems Trainer
HAB	Habitation Module
IS	Instructor Station
ITVF	Integration, Test, and Verification Facility
JEM	Japanese Experiment Module
JSC	(Lyndon B.) Johnson Space Center
LAB	Laboratory Module
MPAC	Multi-Purpose Application Console
MSFC	Marshall Space Flight Center
MST	Module Systems Trainer
NASA	National Aeronautics and Space Administration
NBL	Neutral Buoyancy Laboratory
NST	Node Systems Trainer
POTF	Payload Operations Training Facility
SFD	Simulation Facility Director
SMTF	Shuttle Mission Training Facility
SNS	SSIS Network Simulator
SPF	Software Production Facility
SPOT	Station Proximity Operations Trainer
SSCC	Space Station Control Center
SSE	Software Support Environment
SSIS	Space Station Information System
SSMTF	Space Station Mockup and Trainer Facility
SSFP	Space Station Freedom Program
SSTF	Space Station Training Facility
TDRSS	Tracking and Data Relay Satellite System

session to accomplish the training objective(s).

Joint-Combined. A training session is classified as joint-combined if it involves one or more SSTF trainers plus at least one facility outside the SSTF other than the SSCC.

Integrated. Training is classified as integrated when any of the SSTF trainers participate in a training session with the SSCC.

Joint-Integrated. A training session is classified as joint-integrated if it is an integrated training session that also includes participation of a facility external to JSC.

Figure 2 illustrates joint-combined training sessions. The trainers in the SSTF, along with external facilities, are participating in five training sessions. The Shuttle Mission Training Facility (SMTF), the Space Station Mockup and Trainer Facility (SSMTF) and the Neutral Buoyancy Laboratory (NBL) at JSC are connected to the SSTF in this scenario. In addition, the Payload Operations Training Facility (POTF) at Goddard Space Flight Center (GSFC) and the Integration, Test, and Verification Facility (ITVF) at Marshall Space Flight Center (MSFC) are participating in joint-combined training sessions.

All five types of training sessions are included in the set of sample training scenarios illustrated in Figures 3, 4 and 5.

Figure 3 shows a scenario with five concurrent training sessions. The first training session (represented by the thin solid line) is an integrated simulation coupling the SPOT with the SSCC. For example, the astronaut in the SPOT may be practicing grappling a payload with the Mobile Remote Manipulator System (the manipulator arm) while coordinating the procedure with the flight controllers in the SSCC. In this session the SNS is simulating the data flow between Space Station Freedom and the SSCC via the TDRSS and the DIF. The second training session (represented by the dashed line) is a combined session consisting of one MST connected to a GST. This could be an astronaut practicing environmental control and life support procedures while flight controllers train on monitoring those systems on the ground. The SNS is participating in this session, too. The third session is a stand-alone MST. This could be an astronaut becoming familiar with the operation of the electrical power system of Space Station Freedom. The fourth session (represented by the dotted line) is a joint-combined session with the NBL. The astronaut in the NBL is training for EVA and communicates with an astronaut in the MST to practice the coordination of activities that will be required on-orbit. The fifth session (represented by the thick solid line), like the second session, is a combined session. It has an MST connected to a GST through the SNS. The two NSTs are inactive in this scenario.

Figure 4 shows a scenario which has five concurrent training sessions, the first of which is a joint-combined session with the SMTF. This session includes the SPOT and the SNS in the SSTF and it includes the Fixed Base Simulator (a Space Shuttle simulator) and the Network Systems Simulator (NSS) in the SMTF. In this session the visual systems of the SMTF and the SSTF are synchronized to practice coordination of manipulator arm operations between the Space Shuttle and Space Station Freedom. An example of such an activity is a payload being taken out of the Shuttle payload bay by the Shuttle's manipulator arm and then being grappled by a Space Station Freedom manipulator arm for stowage. The remaining four sessions in this scenario are stand-alone sessions. In these session four astronauts, two in MSTs and two in NSTs, are undergoing solo training.

Figure 5 depicts another scenario with five concurrent training sessions. In the first session (represented by the thick solid line), the SPOT and two MSTs are performing a joint-integrated session with the SSCC and the Payload Operations Integration Center at Marshall Space Flight Center. Since this session simulates communications between Space Station Freedom and ground facilities, the SNS is participating in it. The second session is a stand-alone MST. The

SSTF COMPONENTS

(EXAMPLE)

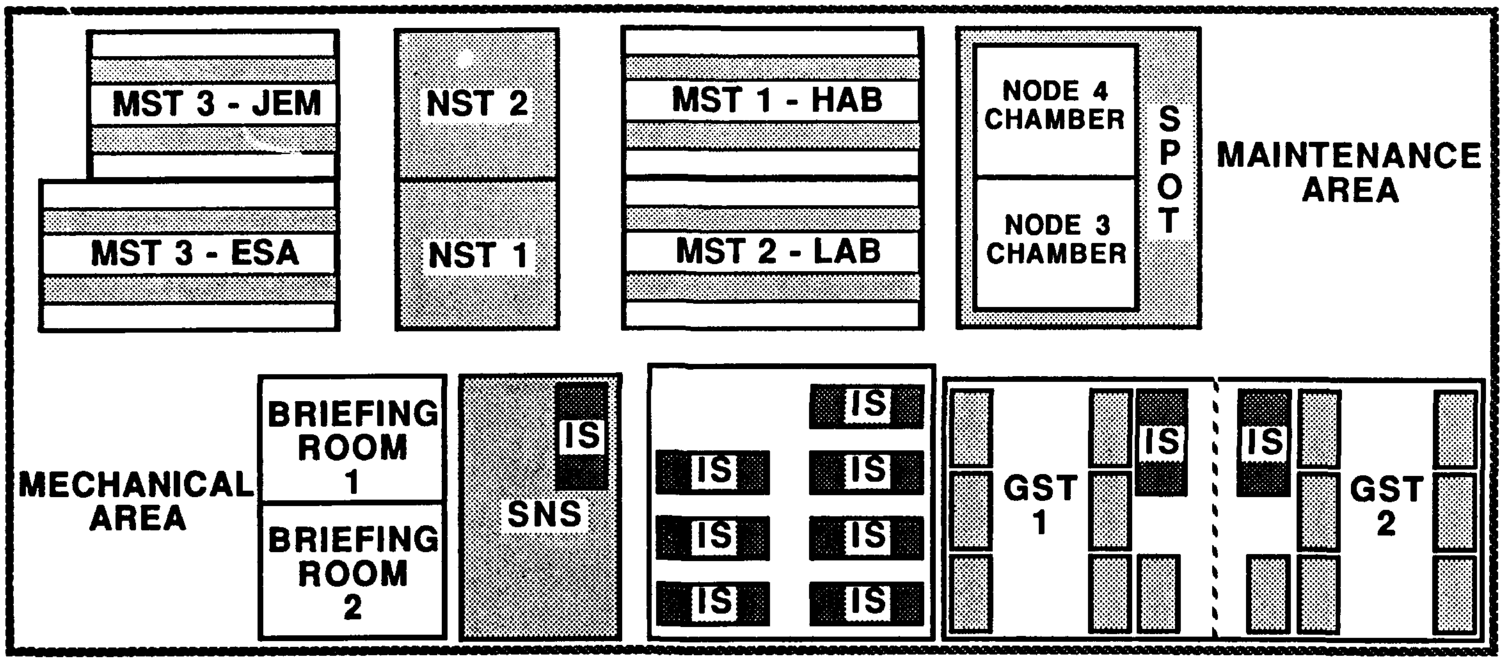

Figure 1

JOINT COMBINED TRAINING CONFIGURATION

(EXAMPLE)

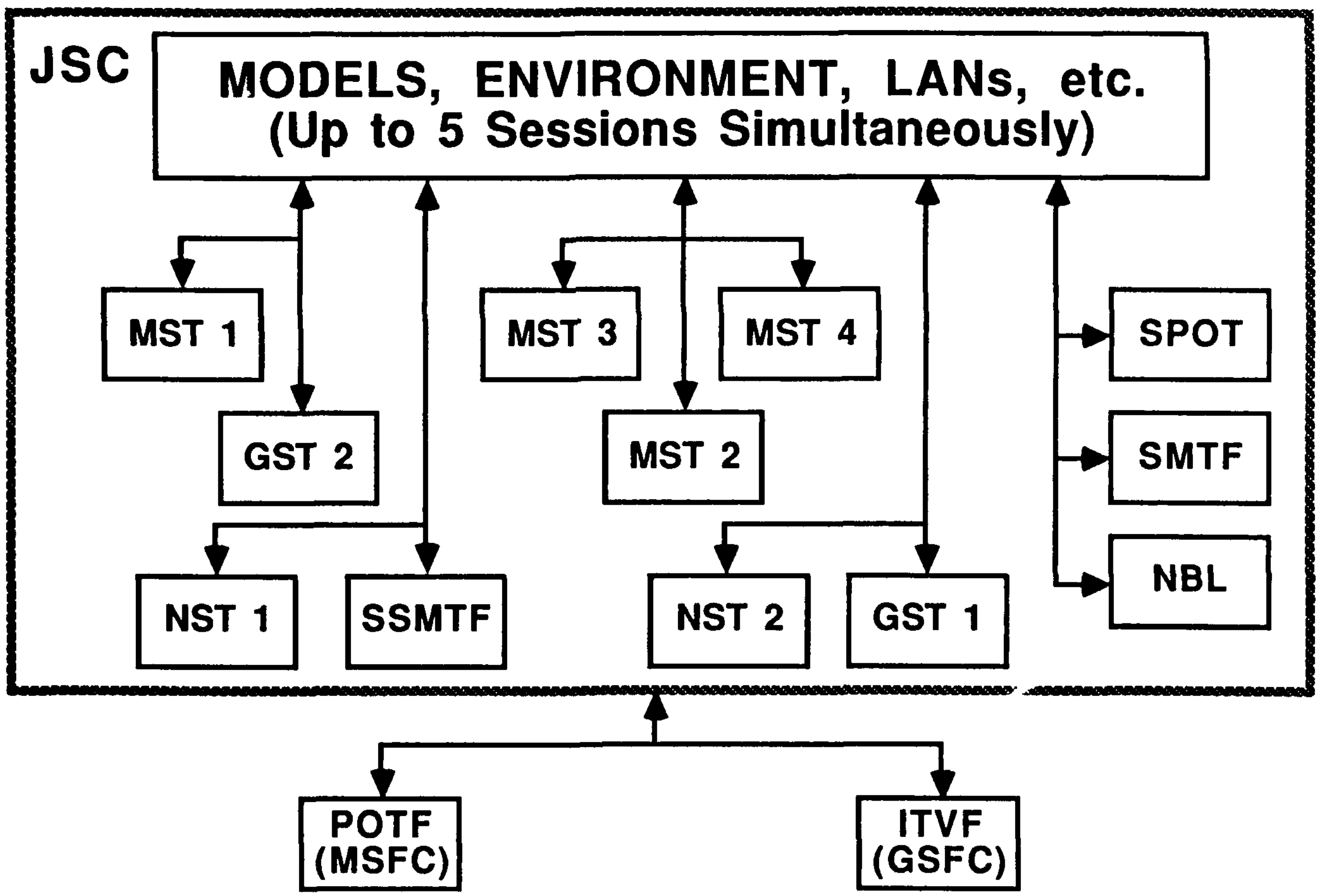

Figure 2

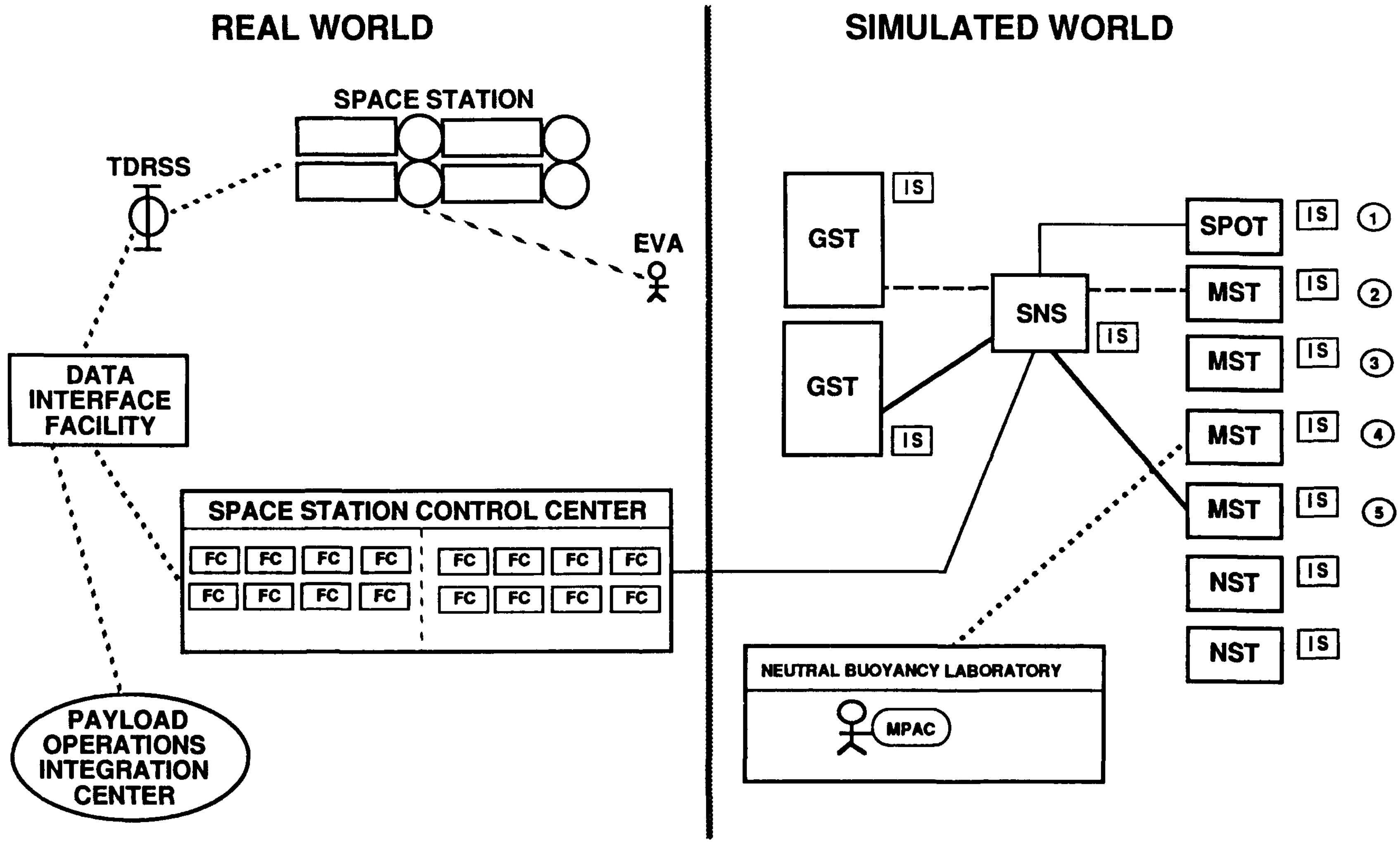

Figure 3: Five Concurrent Training Sessions

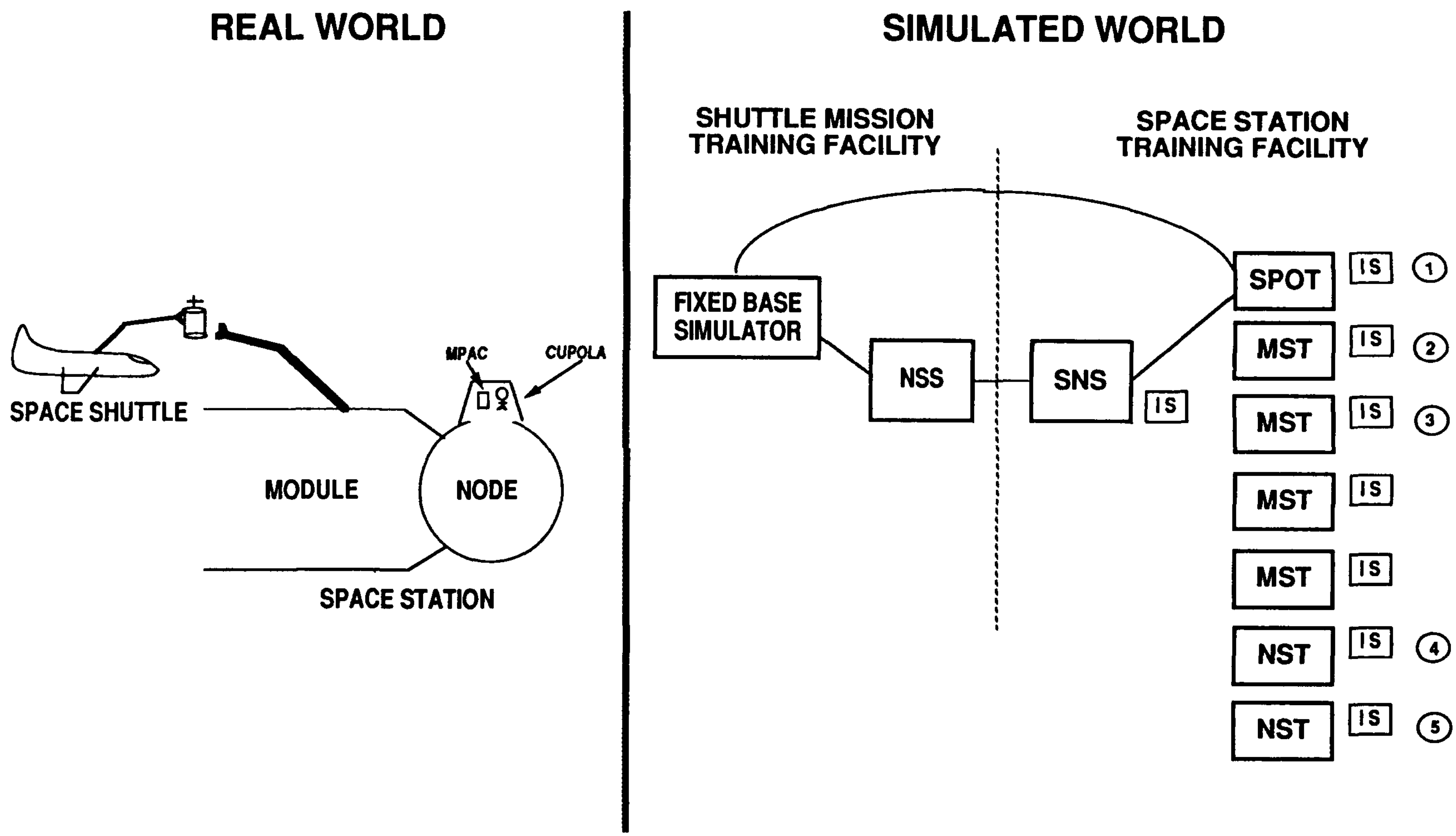

Figure 4: Five Concurrent Training Sessions

AN INSTRUCTOR COMMUNICATION FRAMEWORK FOR TRAINING SIMULATORS

Hilbert Kuiper, Geert F. Slegtenhorst, Rob den Heijer

This paper describes an Instructor Communication Module (ICM) that is part of a Universal Computer Assisted Instruction (CAI) System taking care of the automatic training process in real-time training simulators, such as, for instance, tank- or flight simulator for operator training. The system is based upon a tailor-made training system that was developed some years ago under the supervision of the TNO Physics and Electronics Laboratory.

The ICM supports the tasks of the instructor. To determine what tasks are necessary, a task analysis has been carried out by generalizing the tasks in an existing training simulator. As a result, five main instructor-tasks can be distinguished: System Management, Result Overview, Student Progress, Judgement and Briefing.

The main goal was to make the ICM universal in two ways: firstly, applicable for several training simulators and secondly, workstation independent.

A feasibility model has been developed using the programming language C and the X-window system on a commercially available workstation. The model has one main window for the global overview and other windows can be opened optionally. Direct manipulation and object oriented techniques have been implemented.

The first evaluation results of this model are positive, but give also rise to some adjustments of the user-interface.

Future enhancements include: conversion to the programming language Ada, extension to a full prototype and adding on-line help facilities.

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ROB DEN HEIJER Graduated in Mathematics and Informatics at the Delft University of Technology. During his graduation he worked on the instructor communication user-interface of a Universal CAI System at the TNO Physics and Electronics Laboratory.

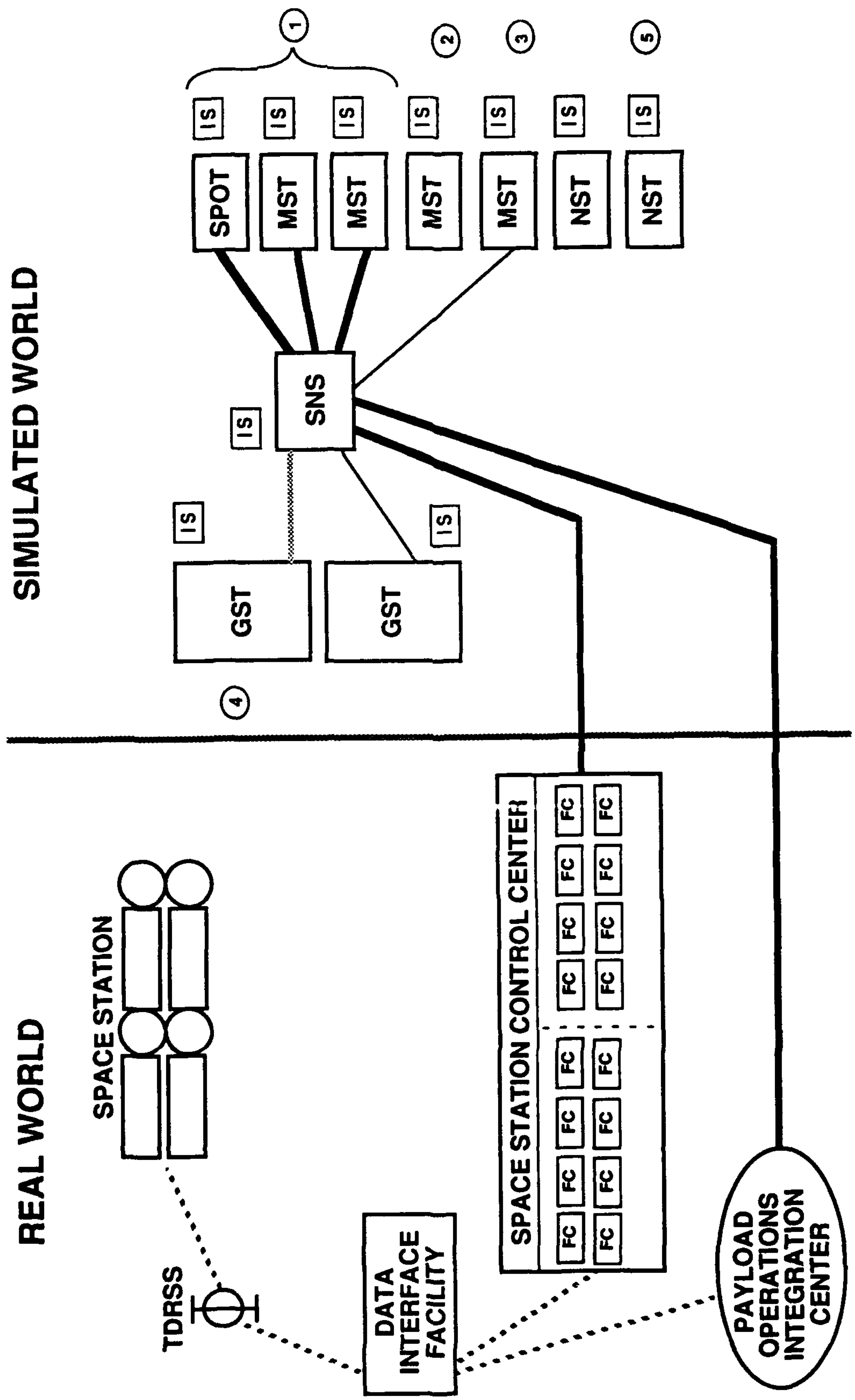

Figure 5: Five Concurrent Training Sessions

AN INSTRUCTOR COMMUNICATION FRAMEWORK FOR TRAINING SIMULATORS

Hilbert Kuiper, Geert F. Slegtenhorst, Rob den Heijer

Introduction In a training situation, such as, for instance, a simulator configuration for training a flight crew or a tank crew, complex and time-critical processes have often to be monitored and judged for several simulators at the same time. The application of Computer Assisted Instruction (CAI) in such a situation is highly recommended.
Only in this manner, it is possible to record what the student is doing during the training-process and to give an objective judgement that is detailed enough.

The Netherlands anti-aircraft tank, the 35 mm PRTL (Pantser Rups Tegen Luchtdoelen), is an example of a system where time-critical processes are important. A training system for this tank has been in use for 40 hours a week, since 1980.
This training-system, the PLT (Pantser Lua Trainer), was developed under the supervision of the TNO Physics and Electronics Laboratory. In the PLT tailor-made CAI has been used in depth. The objective of the system is the training of the crew of two persons in operating the tank.
The crew is housed in the simulator, a feel and look-alike copy of the original tank-turret. The PLT consists of three simulators and is able to train three crews of two persons each simultaneously and independently. In general we will call these simulators or turrets learning stations.

An instructor can monitor the training-processes in the active turrets through an instructor console simultaneously. In this way he gets an overview of the actions and the progress of the crews being trained.
A training system can handle one or more learning stations independently of each other or together as a team.
When operating in the independent mode, all learning stations can follow different scenarios; when operating as a team they all have the same scenario.

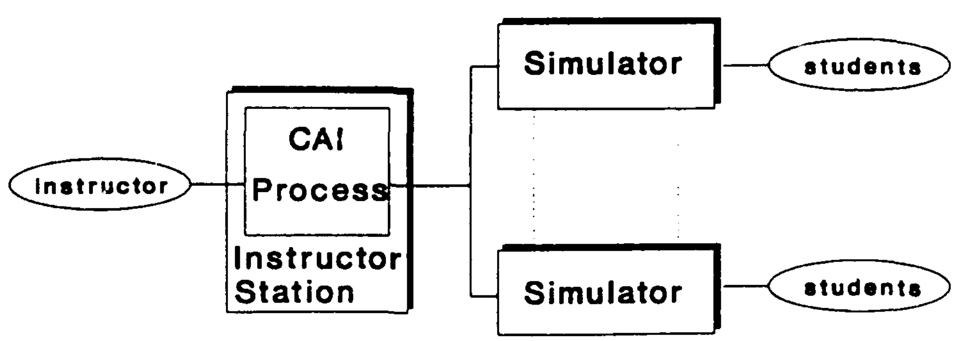

Figure 1 Trainer configuration

Figure 1 shows the training situation schematically, in which the learning stations or simulators are controlled from the instructor station by the CAI-process or by the instructor.
The CAI-process runs on a computer that is integrated in the instructor console. The instructor has access to the system by means of a workstation or, for instance, a console terminal.
The training of the crew in a learning station is divided into several training sessions. A training session is a certain time-period (for instance one hour) in which the crew receives a number of lesson modules. Which and how many lesson modules are followed by the crew depend on their results.

<u>The Universal CAI System</u> At the TNO Physics and Electronics Laboratory, a CAI System is currently being developed, based upon the CAI in the PLT. This system will be universally applicable for a broad range of simulators. The Universal CAI System (UCS) has the advantage that only a single development of the CAI Sytem is necessary and that only the simulator and the interface to the UCS have to be developed for a new application. The basic components of the UCS are depicted in figure 2.

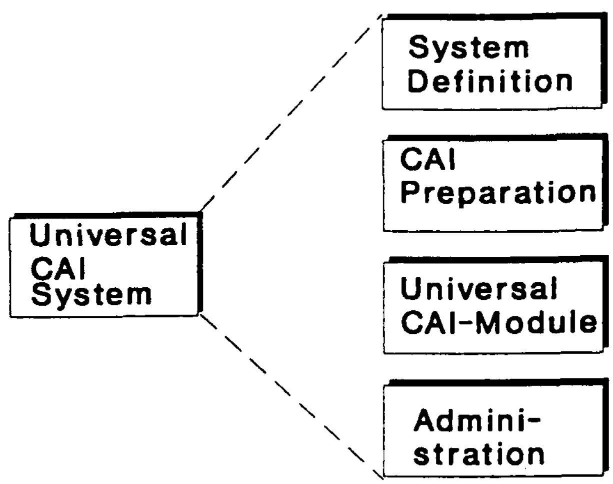

Figure 2 The Universal CAI system

System definition
With this component, the target simulator is specified. All states, switches etc. within the simulator that are relevant for the training, are identified and get a function name.

CAI preparation
The preparation component is responsible for the creation of the lesson modules, in which the scenarios, judging criteria and feed-back messages are defined.

Universal CAI Module (UCM)
This part comprises, in fact, the real-time training. This includes the presentation of the scenarios to the simulator, the analysis of the recorded student actions, the judgement of the results and the determination of the lesson progress (the next scenario). This part is comparable to the CAI-process in figure 1.

Student administration
The data of the students are stored and analysed. These data are related to the history of the student, his results, his weaknesses etc.

At this time, only the real-time training component, the Universal CAI Module, has been prototyped.

<u>The Universal CAI Module (UCM)</u> The UCM, responsible for the real-time training, has an instructional part and a number of modules taking care of the communication with the other parts of the trainer. The larger part of the UCM is platform independent. In figure 3, the components of the UCM are depicted within an overall ICAI-architecture (ICAI-Intelligent Computer Assisted Instruction).

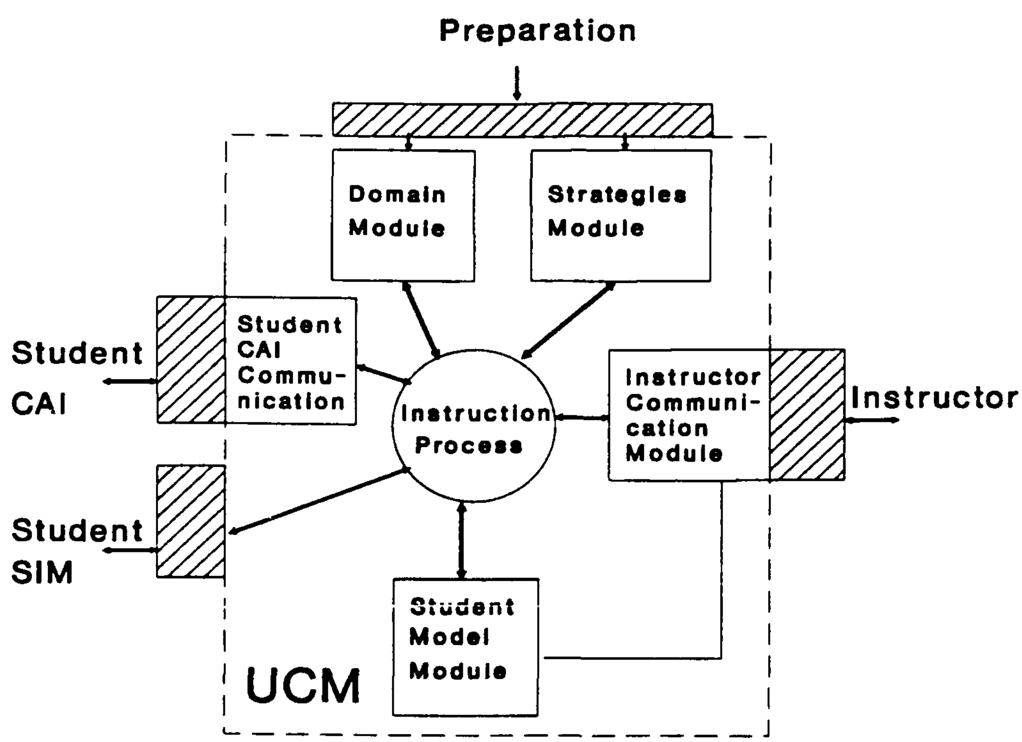

Figure 3 UCM-ICAI Architecture

The main activities of the instructional process are depicted schematically in figure 4.

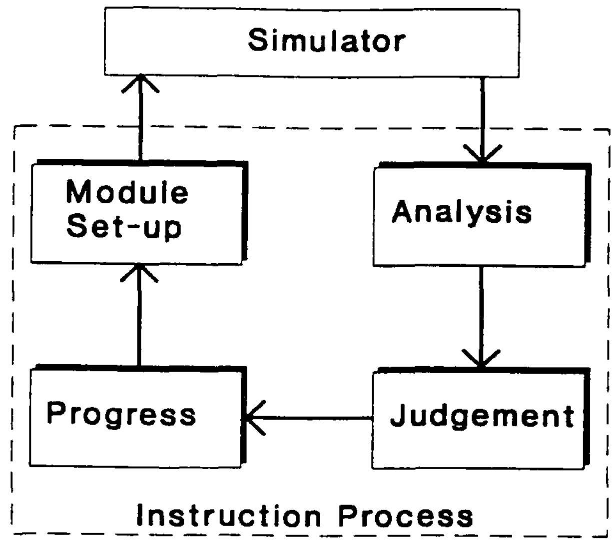

Figure 4 Stages of instruction process

At the start of a session the progress component determines the proper lesson module for the students, based upon their results. After setting up this module, the simulation starts and all relevant student actions are recorded. At the end of the simulation (lasting 3 till 5 minutes) the recorded data are gathered by the analysis component and compared with the ideal situation. A judgement is made up, a score is determined and the process starts again with a new lesson module determined by the progress component.
In certain cases, the progress determination can also be done manually, by the instructor, instead of the instructional process. Scenario and judging criteria constitute, among others, a so-called lesson module, a certain time of simulation. A lesson module can have different shapes. Normally, a lesson module is part of a chain of modules, each presenting a new piece of training material. These modules are called headline-modules. A lesson module can also be a repetition of the former headline-module; in this case it is called a repetitive module. Finally, a lesson module can also focus on a certain aspect of a headline-module, in which case it is a corrective lesson module.

From figure 3 it is clear that the instructional process is communicating with a number of modules:

Simulator communication module
This module receives the recorded actions of the student from the simulator.

Preparation module
This module delivers the prepared library of lesson modules and the lesson network.

Administration module

This module takes care of updating the student's personal data based upon his results during the training.

Student communication module

Through this module the student receives feedback inside the simulator and his response is processed.

Instructor communication module

With this module, the input from the instructor is processed and he gets an overview of the progress in every session.

The remainder of this paper will focus on the instructor communication module.

The Instructor Communication Module The purpose of the Instructor Communication Module (ICM) is the support of the instructor's tasks. This means that the instructor must have the facility to monitor all the training sessions at the same time, wherever he thinks it is necessary. To be able to determine exactly what to support, the tasks of the instructor are specified in detail.

A global partition of the supported tasks is:
- system management
- result overview
- student progress
- judgement
- briefing

The tasks This paragraph gives a more detailed description of the aforementioned tasks.

System Management.

As the administrator of the training system, the instructor has to start up the system and, at the end of all training sessions, must close it down. Also, he has to start up the different sessions. He has to indicate which learning stations are training together, which students are in these learning stations, with which scenario the session is going to start with and at what time the session will be ending. Besides, the instructor sometimes has to abort or end sessions at an earlier time than determined by the system.

Result Overview.

The instructor has to inspect results, should have an idea what the students are doing in their learning stations. This could be globally or in detail. Global inspection means that the instructor can see at glance what sessions are active, what learning stations are in that session, what lesson module is active in the session etc.

Detailed inspection entails that the instructor can monitor the real-time simulation with specific screens in one of the learning stations, but also that information can be retrieved concerning:

- results: what went wrong at a certain lesson module and why,
- progress: what lesson modules were in the session and in what order,
- personal data: student identification and his former results.

Student Progress.

A situation in which the instructor will decide to intervene in the active training process is conceivable. This implies that not the instructional process, but the instructor will determine the next lesson module. The manual determination of the progress may be necessary if the student continuously gets bad results. The student can also ask for an intervention of the instructor. Finally, the instructor himself can decide that manual progress determination must take place. Determining the next lesson module, the instructor can make a choice from one of the following items:

- a headline-module;
- skipping other headline-modules;
- a corrective lesson module; deals with a certain aspect of the headline-module;
- a repetitive module, a repetition of the headline-module possibly with other judgement criteria.

Judgement.

The instructor may have the opinion that the judgement of a lesson module by the instructional process is not completely correct. He can adjust this judgement himself. If he feels that the judgement was a correct representation, but that this was more the result of the individual effort of a single student rather than the pair of them, he can change the score allocation. In both cases, he also acts as a corrector of the instructional process.
The instructor can also enter new scores for certain aspects of the training about which the instructional process is unable to judge, like for instance, the oral communication protocol. In this case, the instructor is supplementary to the instructional process.

Briefing.

Of course, the instructor also has to perform instructive tasks during the training. This mainly takes place by means of oral communication with the student with the aid of an intercom or microphone. Besides the oral communication, the instructor can also send text messages to the learning stations.
Furthermore, the instructor can adapt values in certain registers in a learning station, like for instance, the fill-up of fuel for a learning station used for driving simulation, when the students have used all the fuel.

Task support is activated by the reaction of the module to the instructor's wishes. The module can take care of both global and detailed overviews, belonging to its overview task. It also controls the interface function between the instructor's wishes and the reaction of the instructional process. It is clear that the development of the user interface of this module requires much attention because of its important role.

Designing the user interface A user interface specifies how the system is presenting itself to the user; the human-computer interaction is stated in this user-interface. The importance of an extended design of a user-interface in an early stage of the design process is being recognized more and more. From a functional point of view the instructor module user-interface is an important part.

During the design of the instructor module a graphical window system was chosen as an environment for the user interface. Advantages of this choice are that the initiative and the overview/monitoring lie with the user and that the computer memory usage is low when compared to a command language These user-interfaces also give the users a satisfactory feeling.

In a user-interface based upon windows, the screen is divided into windows: these are functional areas selected by the user which can be sometimes manipulated.
Within the instructor module a main window is functioning as a central functional area, giving a global overview of all current training sessions. Other instructor-facilities can be chosen by means of a menu. In figure 5 we see a hard-copy of this main window.

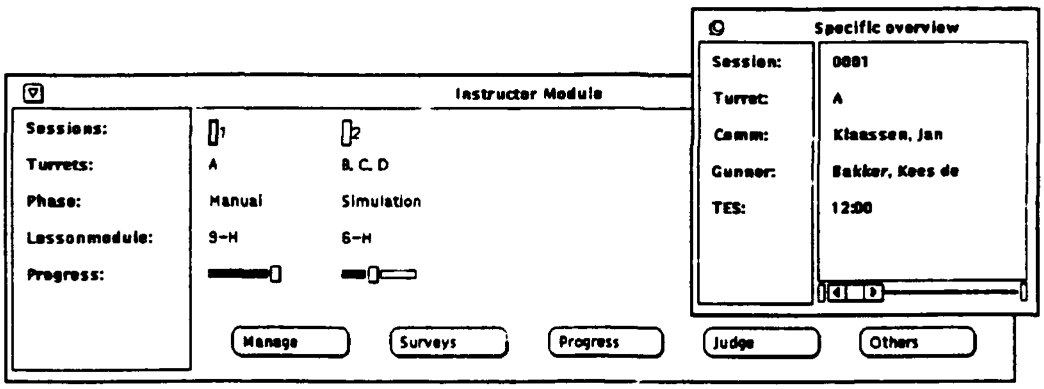

Figure 5 Main menu from the instructormodule

In the global overview we see which training session is active, which learning stations within a session are training as a team, which lesson module is active for them, how far the simulation of the lesson module has progressed, which students are in the learning stations etc.
The menubuttons in the menubar under the global overview are related to the respective tasks of the instructor.

Whereas the main window is always visible, temporary windows can be opened with the aid of menu choices. These could be input for commands screens or screens presenting overviews.
With the aid of the input screen the instructor can specify what he wants to pass through to the instructional process, such as the

determination of the progress or the change of a score. In figure 6 we see an example of an input screen, in which the instructor can determine what progress he thinks is necessary for a certain session.

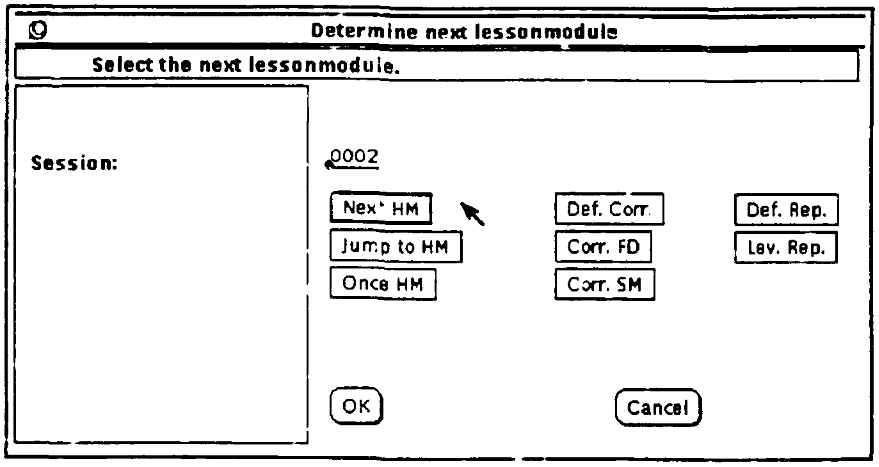

Figure 6 Command inputscreen - progress determination

An overview screen gives detailed information about lesson module results, session progress or personal data. In figure 7 we see a screen with an overview of the session progress. This overview consists mainly of a graphical network of lesson-modules, which depicts what lesson modules have been followed by the students.

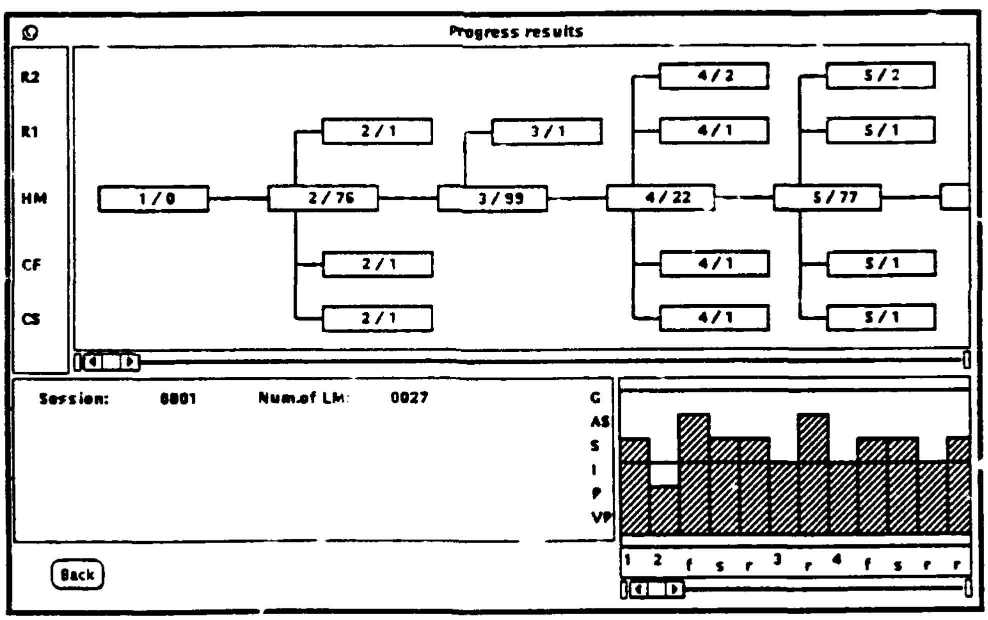

Figure 7 Overview of session progress

Object oriented approach An important part of user interfaces based upon windows is direct manipulation, i.e. the fact that the user can manipulate certain objects on the screen, like select, move, enlarge etc. This is also called object orientedness.

The instructor module user interface shows the object orientedness in different ways. For example, the instructor can select the global overview of sessions with a mouse. By selecting a session, the contents of the global overview is specified in detail.
The lesson modules in the network overviews are also shown as objects which can be manipulated. By selecting a module (a rectangle in a network, see figure 7) a pop-up window appears, giving more detailed information concerning this lesson module.
Because of the many positive experiences with an object oriented approach and with direct manipulation, these items will be used more and more in the future in the instructor module.

Evaluation and conclusions Although the development of the instructor module and the UCM is still in progress, a number of demonstrations with the feasibility model were given and a first evaluation with expert users from the school took place. The first reactions show that the instructor module satisfies the requirements of the user, the instructor. It is now plausible that the instructor module is sufficiently universal, i.e. applicable for other trainers.

It turned out that the instructor module is a good step in the direction of an instructor communication which can combine the necessary freedom for the instructor with the automatic instructional process of the UCM. However, some guidance of the instructor is still necessary in a window environment.

In the future, when the instructor module has been developed into a full prototype, more attention will have to be payed to the possibility of presenting data through graphic overviews, together with an object-oriented approach of the user-interface.

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List of keywords:

Computer Assisted Instruction (CAI)

Intelligent Computer Assisted Instruction (ICAI)

Computer Based Training (CBT)

Training Simulator

Real-time Simulator

Instructor Station

Trainer

COMPUTERIZING A JOB SKILLS INVENTORY

Dr. DeLayne Hudspeth

The process and results of automating an Air Force Job Skills Inventory is reviewed. A prototype computerized survey was used to determine that computer administration is feasible and seems to yield a higher number of job task selections than does traditional administration. Rationale for this finding are provided. This project also raised a number of research questions both of the survey used and more generally in terms of systematically using computers to collect test and questionnaire data. Specific questions that concern the moment of contact between the respondent and computer administration are detailed. A plan for using a Bulletin Board System and collaborative research is discussed.

Dr. DELAYNE HUDSPETH Associate Professor in the Area of Instructional Technology, College of Education, The University of Texas at Austin (78712) enjoys teaching a variety of courses including ITV Studio Production, TeleCommunications, Analysis of Research in Instructional Technology, Systematic Design of Courseware and Management of Training. His research activities include the use of Bulletin Board Systems to support teachers, Feedback and Feedforward, Distance Education methods and the effect of Case Studies on Higher Level Objectives. He recently received a Summer Research Fellowship at the AF Human Resources Laboratory, Division of Manpower and Personnel at Brooks Air Force Base, which provided the background for this paper.

Computerizing a Job Skills Bank

by

Dr. DeLayne R. Hudspeth

Introduction

The Occupational Measurement Center (OMC), located at Randolph AFB, Texas is responsible for the preparation, administration and analysis of job classification surveys within the USAF. Currently, the time between survey mailing and initial data processing ranges from seven to nine months. The OMC judged that current methods of obtaining and processing data for occupational analysis studies is slow, complicated, and expensive. The OMC subsequently asked that the AF Human Resources Lab, Manpower and Personnel Division, (AFHRL/MOD) investigate a quicker, more efficient system of administering occupational job surveys. Of particular interest was the possibility of automating the process through personal computers and the use of the DDN for distribution.

A full report of this research is available from AFHRL/MOD (Brooks AFB, TX 78235) and is only briefly reviewed in this paper. The purpose of this presentation is to describe the developmental stages incurred in computerizing a data bank and to describe the critical issues facing technologists as we move toward automating job inventories, tests, questionnaires and other data bases. Traditional forms of survey and test administration offer some advantages to both teacher and learner; and, so does computer administration. Care and additional research are needed to optimize computer use.

Objectives of the Survey Automation Research Project Five objectives were defined as outcomes for my summer project: 1) to create a computerized version of the Chapel Management Job Survey (chosen because it was about to be administered via traditional means); 2) to prepare a research design for comparing the two forms of administration; 3) to collect data; 4) to analyze the data and describe the results; and 5) to provide recommendations for R&D based on our insights and experience.

Computer-based Chapel Management Job Inventory A computer-based job inventory was developed using Microsoft's QuickBasic version 4.5. This third generation language is internally well documented and allowed us to write, test and place software in the field in less than four weeks. Modular development and formative evaluation was used throughout this process.

The software consists of two independent modules that are chained together. The first module contains the Biographical and Background Sections, has 13 subprocedures and 2576 lines of code. The second module is the Duty-Task Section, contains 18 subprocedures, 1341 lines of code and serves two major functions.

The first has the incumbent reviewing each of 407 tasks and identifying the ones done in his or her job. The second procedure consists of the job incumbent rating relative time spent, with a nine point scale, only those tasks identified in the first procedure. In both procedures the incumbents could back up and review or change answers and ratings.

To summarize, information generated from the second module included the identification of tasks done by incumbents in their present job and time rating data for each task; and (for research purposes) amount of time spent in using the module, times an incumbent backed up and changed an answer and how many error messages were written to the screen. All data were written out to data files and captured on floppy disks.

<u>Research Design</u> The two independent variables were form and sequence: the two forms were paper/pencil (P) or computer-based (C); and, three types of sequence, 1) P followed by P, 2) P followed by C, and 3) C followed by P. (Note: Although the fourth variation of C followed by C would have been desirable it was a condition of using this population that all persons must take a paper/pencil survey. We judged that asking airmen to take the same inventory three times would affect reliability of the data.)

Test/re-test procedures were used for comparing the two administrations and each respondent served as his or her own control. This was necessary as no assumption could be made about the central tendency and dispersion of scores. Each respondent had a unique pattern of responses which described his or her job.

The three treatments were:

	Time 1 (T1)		Time 2 (T2)		Original N
Treatment #1.....	P	followed by	P	(P-P)	40
Treatment #2.....	P	" "	C	(P-C)	20
Treatment #3.....	C	" "	P	(C-P)	21

The purpose of treatment #1 (P-P) was to provide a baseline against which the other treatments could be compared with respect to the variability of test/re-test. Although a perfect match was not expected, a reasonably high match was anticipated, as jobs seldom change much in two weeks. (Time between all treatments was 2-3 weeks.)

The P-C and C-P treatments provided comparison data to examine effects due to form of administration. For example, the second survey might yield a higher number of tasks selected than the first, since the first administration might sensitize incumbents to the nature of their jobs. However, this effect could be confounded for the P-C and C-P sequences because it is possible that all C administrations would yield a higher number of responses because C respondents are forced to look at each

separate task whereas with the paper version they might accidentally scan past a relevant job statement.

Administration and Data Collection About May 24, (1990) a printed survey (P) which included the usual optical scan data function was sent by OMC to all AF bases using traditional means and methods of distribution. The first incumbents whose surveys were returned to OMC were immediately sent a second P administration with an explanatory letter. By July 5, 30 second returns were received and used for analysis.

For research, printed surveys for the P-C treatment were hand delivered to the Survey Control Officers (SCO) at Bergstrom, Kelly and Randolph AF bases. The computerized version was then given within 2 - 3 weeks following the paper administration. For all computerized administrations, local Z-248 PC's were used and scheduled by the Chapel POC. Each respondent used a separate disk for taking the survey. For the C-P treatment a reverse process was used starting with Brooks and Lackland AF bases. All paper versions were machine scanned by OMC to create a data file on disk, which was then matched and merged with the data strings collected via the PC's.

Results Because the full data are reported elsewhere (see above for the full technical report due from AFHRL/MOD early 1991; and, in the proceedings of the 1990, 32nd Annual Conference of the Military Testing Association) I only provide summary data in Table I and II. Based on this and other data not provided here, I will briefly summarize my personal conclusions of this project and then move to define some of the critical issues related to computerized survey and test design and administration. Because the size of this (convenience) sample is small and central tendency can not be assumed, generalization from the data is severely limited.

Perhaps the most important benefit of the summer research project is that the Air Force has a prototype computerized job survey to demonstrate the potential of automated administration. A

Table I
Summary of Data

	N=30		N=17		N=17	
Treatment	P1	P2	P1	C2	C1	P2
Total tasks select.	3,684	3,878	1,808	1,950	2,418	2,267
Mean each Ss.	123	129	106	115	142	133
Selected both adm.	81%		82%		75%	
Mean change	+6.5%		+8.4%		-8.9%	

job survey was administered with a microcomputer (and could have been distributed via network), the data were captured

electronically and analysis was accomplished in a few hours without the need to handle paper questionnaires and optical scan sheets. Although this accomplishment may seem trivial to those who routinely administer questionnaires and tests via computer, in complex organizations a working prototype is sometimes useful.

We found that the computer version consistently captured more job tasks than did paper administration (see Table I, above). This can be explained when considering that the paper version, in my opinion, suffers from readability factors, and it is easy skip over similar looking task statements. Whereas, with the computer version the respondent must lock at every task statement, and overtly respond, before seeing the next task description.

Another research issue was whether, for the job tasks selected by incumbents, the estimates of "Time Spent in Present Job" would vary as a function of type of administration. (This is estimated with a nine point scale; 1 = "Very small amount"). Table 2 shows, where the same job task was identified in both administrations, the change in ratings from the first administration to the second. For example, for the P1 - P2 administration of 2,988 tasks chosen 1,283 time ratings were the same, 387 estimates were one point higher for more time spent; 342 estimated one point less time spent, etc.

Table 2

Time Spent Estimates for Jobs Identified Both Administrations

N = 30 P1 - P2			N = 17 P1 - C2			N = 17 C1 - P2		
Change	# of Tasks		Change	# of Tasks		Change	# of Tasks	
-8	0		-8	3		-8	9	
-7	1		-7	2		-7	9	
-6	2		-6	3		-6	16	
-5	10		-5	11		-5	27	
-4	74		-4	60		-4	74	
-3	124		-3	41		-3	113	
-2	239		-2	116		-2	229	
-1	342		-1	154		-1	364	
0	1,285	67%	0	560	64%	0	657	64%
+1	387		+1	231		+1	133	
+2	281		+2	137		+2	89	
+3	146		+3	84		+3	62	
+4	76		+4	78		+4	19	
+5	11		+5	6		+5	4	
+6	8		+6	2		+6	6	
+7	1		+7	0		+7	1	
+8	1		+8	0		+8	0	
	T=2,988			T=1,488			T=1,812	

If one assumes that, on a nine point scale, it is reasonable to vary by one point in re-estimating relative time spent on each

separate job task statement, we find that for the three treatments that 67% (N=2,014), 64% (N=945) and 64% (N=1,154) were consistently rated from the first to the second administration. Although the distribution of these re-estimates generally resemble a normal distribution, further analysis of why some incumbents varied so much awaits further research, probably using qualitative methods such as "think aloud" protocols or other means of collecting individual reasons. Also, in the C1-P2 treatment there seems to be a shift toward estimating less time with paper. A replication study is needed to see if this shift is spurious.

I would also note in passing that some of the variability we observed in estimating the relative time spent on each job task, may have been a function of survey instructions. Specifically, there were both data and informal feedback to suggest that the directions for estimating "Time Spent..." could have, by the incumbents, more than one meaning. Subsequently, we recommended that additional research address this issue.

<u>Summary of "Automation of Job Surveys" Recommendations</u> Briefly, we recommended that the USAF begin immediately to automate the administration of job inventories. Full automation includes three primary issues. First, a comprehensive electronic network needs to be designed that will allow OMC to electronically distribute, administer, process and archive occupational surveys. "Personnel Concept III" (PC-3) currently under development by AFMPC, with gateways through each AF CBPO, should be investigated further. Second, because the computer offers display, review and reporting capabilities not available with traditional paper administration we strongly recommend that planning efforts to use this capability be undertaken as soon as possible. Specifically, a policy review of occupational data needs might surface manpower reporting needs which new technology could address. Third, research is needed to optimize design of computerized surveys which might include branching or mapping, differential feedback based on individual patterns of response, procedures for review and correction of responses by incumbents and other survey design functions which are unique to the computer.

<u>Computerizing Tests and Questionnaires</u> During preparation of the computer based job inventory described above it became apparent when reviewing the literature that relatively little research has been done to help optimize the design of computerized tests and questionnaires. This issue is especially important when considering the unique potential of the machine to process results and provide differential displays based on user input. Although there is a modest base of psychometric data, and increasing interest in, adaptive testing, this is but one of many approaches that should be considered.

My interest is driven by two concerns. First, I am concerned that some persons will presume that what works well with paper and pencil will work equally well with the computer. I suggest that this transfer process poses very real issues of reliability

and validity. Second, I am concerned that the potential of automated data capturing will be lost if we do not carefully think through the design and administration issues of automated testing and carefully document the cost/benefits. The habits that we form early are hard to break later, even apart from the technical issues of data file standards, etc.

One way to approach the problem is to consider a given test or questionnaire as the hub of a system. This system can be defined simplistically as the institutional need (represented by the teacher or designer of the test or questionnaire), the medium used such as a computer, the testee and his or her interface with the medium, feedback to both the testee and tester, and effect of the data on the system.

For the purpose of this presentation let me focus just on the person taking the test, the testee, and those moments of contact wherein a CRT display and keyboard are used to capture the knowledge, skill and attitudes of a person whose promotion or job may be on the line. Research questions include:

- What are the minimum keyboard skills needed? Do these skills interact with the type of test given (such as multiple choice, essay, constructed response, matching)?

- Does the respondents attitude toward a computer affect the reliability of responses (Hawthorn effect? Computer phobia?)

- Is readability the same for a CRT as for print material; for monochrome and color; equal for all standards such as EGA, VGA?

- What are optimum construction guidelines for number of items, length of sentence, placement of distractors?

- What are the effects of different response modes (cursor control; A,B,C vs. 1,2,3; forced choice vs. open response).

- If scales or graphs are used on the CRT is some level of graphic literacy required? Can print-based measures be applied to CRT display?

- If pictures are used on the CRT as a source of test material how does limited resolution and color shifts affect the ability of the testee to discriminate; how does this interact with the purpose of the question?

- Testees sometimes scan an entire test, before responding, for an overview and for pacing. Does lack of this ability affect some testees more than others? Affect distribution of results?

- On most tests and questionnaires the testee can review and change an answer. Is reverse scrolling and answer changing important? For whom? Why?

- A computer can analyze data and create unique displays for summary review and "map" appropriate items to add or delete. What are guidelines for using this capacity? How is scoring accomplished with multiple pathways? How is reliability of such tests determined?

The list could go on. The point is that innumerable questions can and should be raised, some more important than others, concerning our ability to use computers for data collection. Further, when we consider the rest of the system and supra-system needs, we move into: standards of design; data transmission requirements; operating system needs to suit various equipment bases, archival standards for both the instruments and the data, up-grade requirements for better and faster equipment (such as high definition TV) and, a host of other issues.

I have chosen to focus on that moment of contact between the respondent and the machine and in the future will be proposing a program of research to address the specific issues of man-machine interface. I anticipate continued collaboration with the Air Force Human Resources Lab at Brooks Air Force Base and propose that we establish a special interest group to work within and between institutions. By December 1, 1990 I hope to have a Bulletin Board System that can be used to share and develop ideas, coordinate research efforts and provide a data base.

The next step is to review and evaluate existing research to determine what works. From this data base we can determine what is needed and create a long range program of research efforts so that each one of us might address, with minimum redundancy, some aspect of the overall need. The problem is a bit like eating an elephant, the first task is to carve it into manageable chunks! Finally, I am proposing the development of a research tool or "shell" that will allow researchers to select from a menu various dependent and independent variables and have these automatically formatted for computer administration. I hope to report on this effort at the next TITE conference.

Summary of Issues Facing Computerization Relatively little research is available which can be used to guide the design of computerized tests and questionnaires. Elements of this issue involve format issues (such as the optimum number of items displayed at one time, the effect of scrolling, optimum placement and format of instructions); the effect of prior computer experience (keyboard skills, fear of using a computer); scaling methods (optimum scaling techniques which use the medium of CRT and keyboard); and, the costs and benefits of using the unique potential of the computer (such as mapping or summary reviews based on a pattern of responses).

Proposed A special interest group is proposed that would communicate with a Bulletin Board System (further information can be obtained via BitNet; DeLayneH@UTXVM). Current efforts include a review of research to determine what works; collaboration to address gaps in this data base; and, the design of a research productivity tool or "shell" that will allow researchers to automatically format computer based tests and questionnaires for electronic delivery and rapid data analysis.

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EVALUATING TRAINEE PERFORMANCE
ON SIMULATION TRAINING SYSTEMS

John E. Biegel, Murat Draman, Catharina Eeltink

Intelligent Simulation Training Systems require an Evaluator module that will automatically and intelligently assess trainee performance. In some domains a trainee's response can be categorized dichotomously, e.g. right or wrong. In most domains, particularly in those domains where training is accomplished using simulations, there may be several correct trainee actions for each and every scenario. Some responses may reflect more advanced levels of skill acquisition than others. In this situation the Evaluator must score the trainee's response relative to a set of possible correct actions which an expert would find acceptable.

The University of Central Florida, Embry-Riddle Aeronautical University and the General Electric Company at Daytona Beach are working together to build an Intelligent Simulation Training System (ISTS). Currently, it is in a prototype state. The demonstration domain is Air Traffic Controller (ATC) training. One of the significant tasks has been to build the Evaluator module. The Evaluator takes an input from the trainee, compares it to a set of actions that an expert ATC might take, and makes an evaluation.

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Introduction

Intelligent Training Systems (ITS) are the way of the future for training in motor-skill tasks. Many of these systems will be simulation-based. In a broad and generic sense, we can view the objective of simulation-based training systems as training for the proper manipulation of objects in time and space. This is true for training a missile operator, an air traffic controller (ATC), a sonar operator, a tank driver, a truck driver, etc. Other domains where the same or similar principles apply involve diagnostics or operator training for a power plant. In some of these cases the simulation training process involves only the identification of irregular conditions or abnormal conditions and the proper corrective actions. In a sense, ATC training might be considered one of the most difficult because the trainee and the simulator alternately drive the process. (When the trainee enters an acceptable input, the simulator uses the new input as a modification to the direction in which to proceed until the next input). The simulator may also be internally modified by the tutorial component to alter a simulation scenario. This is done dynamically, as a system reaction to the trainee's current performance. The Evaluator's task is to determine relative correctness and quality of the trainee's input. The process of evaluation expands with each added rule and each added feature of the system. (Note: At present no cognitive evaluation of learning styles or reasoning processes is carried out. The Evaluator only assigns a quantitative score to the trainee's response based on what it accomplishes.)

The Intelligent Simulation Training System (ISTS)

The Intelligent Simulation Training System (ISTS) is a generic system with eight generic components and two domain dependent components. The generic components are the Control, Inference Engine, Translator, Input Filter, Interface, Tutor, Student Model and Evaluator. The Domain Expert (DE) and the Domain Expert Instructor (DEI) contain domain-specific knowledge bases. The DE knowledge base is partitioned into two components: a component that detects events that require trainee intervention (the Domain Expert Problem Finder or the Intelligent Pre-Processor) and a component that generates suggested actions (the Domain Expert Problem Solver). The DEI incorporates all domain-specific information for creating/modifying a scenario and for evaluating the actions of the trainee. The generic components-/modules that need domain knowledge (i.e. the Tutor and the Evaluator) obtain it from the DEI and the DE. The simulator, of course, must be programmed to display the proper objects and their appropriate actions, identification, parameter values, etc. (A generic simulator could be programmed in an object-oriented language so that the required parameter values, etc. are instantiated at initialization.)

The purpose of ISTS is to take over the active training duties of an instructor. The instructor's role will be that of a learning manager who establishes the content (types of events that are traced, difficulty level of the scenario, etc.) and evaluation principles (topic weights, importance of events and their status, etc.) of a planned training session. Once a trainee starts

a session, the Tutor component of the ISTS takes over to integrate the instructor's criteria.

The Training Components

The modules within the ISTS which directly assess trainee performance are the Tutor, the Student Model and the Evaluator. These three components act in a cooperative manner to adequately, efficiently and effectively train the trainee. These modules may utilize knowledge residing in the DE and the DEI, but the DE and The DEI do not react to trainee inputs directly. The role of the Tutor is to determine the appropriate training for the trainee at all points in the training process. To do this, the Tutor obtains information on the trainee's status from the Student Model, and evaluates that information in light of the trainee's current performance, past performance, the difficulty of the scenario, the objective of the current lesson, etc. The Tutor then decides to decrease, increase, or maintain the intensity and difficulty of the training based upon the above evaluation process. At times it provides immediate feedback to the trainee. It can also provide "help" and "advice".

The role of the Student Model is a benign one of record keeping. The past performance record is loaded at initialization. The Student Model updates the trainee record as the training process proceeds and saves it at the end of a session.

The role of the Evaluator is to first score the trainee input in terms of its domain appropriateness (see next paragraph). If the input is accepted, the Evaluator then evaluates the input's effectiveness relative to what an expert would do under the same conditions.

Determining the Acceptability of an Input

There are several tests which a trainee's input must pass prior to its being sent to the simulator for execution. An input which does not pass these preliminary tests is rejected, scored as a failure, and no further processing is necessary. (Note: The following tests are specific to the ATC domain, but may apply more broadly.)

The first test on the trainee input is for correct spelling. Incorrect spelling must be evaluated while the trainee is learning the keyboard. At present inputs are entered by keyboard. This adds a component to the evaluation process which would not be there if we were using voice input, a future enhancement. After this initial learning phase, incorrect spelling must be rejected without affecting the trainee's record. Such a situation will not be encountered with voice or menu driven interfaces.

If the spelling is correct, the input is tested is for proper syntax. Syntax errors reflect deviations from the precise command/input format required by a particular domain. The significance of syntax errors could vary depending upon the lesson objective.

The third test is for the appropriateness of the input to the physical environment: Does it conform to speed restrictions, altitude restrictions, forbidden air space, (etc.)?

The fourth test is for appropriateness with respect to the object; i.e. can the airplane achieve the given speed, altitude, etc.? This test applies only in a general sense since a controller cannot be expected to know

all of the characteristics of all models and versions of all aircraft under all load and weather conditions.

Additionally, this test also verifies logic errors: the trainee may ask a plane to descend to 12000 feet, while the plane is already cruising at 10000 feet.

The fifth test concerns whether the pilot accepts the input. The pilot can reject an instruction (for example, being told to fly directly into severe weather), although normally instructions are accepted.

An input that fails one of the above tests is rejected with an explanatory message. The Evaluator then assigns negative points under phraseology-error, environment-error, logic-error, argument-error, or object-error categories.

Tracing the Effects of a Trainee Input

Once an input has passed the above tests, it is translated into a format that the simulator understands. The system constantly keeps track of a "snapshot" of impending events associated with each object (plane) in the simulator. A new "snapshot" of impending events for the modified object is taken after the trainee input is implemented. This new list is compared to the previous list of events which involve the modified object. The difference shows the effects of the trainee input on the simulator. The trainee input is then evaluated based on the impending events that are eliminated, unaffected and created. The type, quantity, and status of these events are taken into consideration. If an input affects none of the events, it is an ineffective input. Typical events in air traffic control are potential safety/separation violations between airplanes, emergencies, handoff procedures, etc. Each event represents a situation that the trainee must eliminate, or a procedure that must be executed. There is a one-to-one correspondence between the current set of events in a simulation scenario and the responses/actions required of the trainee. Each event has appropriate time tags that are used in determining the status of the event. One time tag represents the latest time by which they must be eliminated in order to avoid trainee intervention delays and critical/fatal events. Another time tag marks the detection time for the event. This tag is used for determining how long the event is left unattended, or how long it took the trainee to eliminate it. An instructor (in the classroom) specifies the time interval to be used for determining when the event reaches a "critical" status. An event is given a "late" status if it is still present after its latest-elimination time.

A typical trainee input may: (1) eliminate one or more events ("simple elimination" input), (2) create one or more events ("simple creation" input), (3) eliminate events while creating other events ("side-effect" input), or (4) cause no changes in the snapshot ("inefficient" input). The input is classified into one of these four categories.

Evaluating a Trainee Input

For each type of event, the instructor specifies a starting score, and a series of correction factors. These are used for determining the number of points to be added to or deducted from the current score for a type of event, each time such an event is found to be created or eliminated.

With a negative point value, the instructor may specify that the creation or elimination of a type of event is undesirable. As an example, creating a potential separation violation between two airplanes is considered undesirable. The trainee may be given positive points for eliminating such an event before it becomes critical.

The correction factors are used for distinguishing the scoring for new/eliminated events based on their status:

- non-critical events created by a simple-creation input,
- immediately critical events created by a simple-creation input,
- immediately late events created by a simple-creation input,
- non-critical events created by a side-effect input,
- immediately critical events created by a side-effect input,
- immediately late events created by a side-effect input,
- non-critical tutor-created event eliminated without side-effects,
- critical tutor-created event eliminated without side-effects,
- non-critical tutor-created event eliminated with side-effects,
- critical tutor-created event eliminated with side-effects,
- non-critical trainee-created event eliminated without side-effects,
- critical trainee-created event eliminated without side-effects,
- non-critical trainee-created event eliminated with side-effects,
- critical trainee-created event eliminated with side-effects,
- neglected (late) event initially created by a simple-creation-input,
- neglected (late) event initially created by a side-effect input, and
- neglected (late) event initially created by the Tutor.

The trainee actions are also evaluated by comparison to expert suggestions. The trainee action with undesirable side effects will not have its match in the set of expert suggestions. A trainee action without side-effects will match one of the expert suggestions that are ordered by preference and efficiency. This ordering is accounted for in the evaluation, as the system determines if the trainee utilized the most preferred solution or a less desirable alternative. An apparently correct trainee action without a match in the expert suggestion set may be considered imperfect and evaluated accordingly.

Inefficient inputs are classified into four categories:

1. inefficient inputs: there are no events (therefore no required interventions) associated with the modified object. The trainee is focusing on an object that does not require any attention.
2. No-match inputs: there is no similarity (no key-word match) between the trainee input and a suggested expert action. The trainee tried to use an unrecommended instruction to eliminate an existing event. Example: the trainee climbed the plane to a new altitude without successfully eliminating any of the pending problems, while the expert suggests turning the plane to a new heading.
3. Partial-match inputs: there is a key-word match, but no argument match. The trainee used a proper action, but with

specifications that are not in the suggested range. Example: The expert suggests climbing the plane to an altitude between 18000 and 20000 to eliminate a pending violation, the trainee asked the plane to climb to 17000.

4. Perfect-match inputs: there are key-word and argument matches between the suggested expert action and the trainee input. The input should have eliminated the pending event. There is a problem with the Domain Expert. The event is not detected properly, or the expert suggestions are not correct.

The instructor may specify points to be deducted for the first three categories of inefficient inputs. No evaluation is done for the forth category.

Similarly, if an input creates side-effect events, the comparison with the expert actions list should not produce a perfect-match. If the trainee executed an action suggested by the expert, no side effects should have been caused. The side-effect events are not detected properly, or the expert suggestions are not correct. No evaluation may be done in this case.

Separate scores are kept for (a) each type of event traced by the Simulator, (b) the input errors done by the trainee, and (c) the ineffective inputs. The final score is a weighted average of the scores in these different areas with the weights being determined by the instructor.

Conclusion

The Evaluation strategy explained above is completely generic. It may be applied to any domain which involves temporal-spatial reasoning. Events may be created or eliminated. Creation or elimination of events may be desirable (correct) or undesirable (incorrect) outcomes of the trainee's manipulation of the objects in the simulation. The trainee's interventions are compared to a Domain Expert's set of possible correct interventions and scored according to how closely the trainee's input matches the Expert's solutions. The scoring remains generic because the point values assigned to trainee actions are initially provided by the Domain Expert Instructor. The Evaluator does not contain any domain-dependent information. It only has the general structures needed for tracing and assessing the possible results of procedures which could conceivably be carried out on objects located in space and time. Having defined these general procedures, the specific values associated with them are determined by the instructor, integrated in the Domain Expert Instructor, and sent to the Evaluator at run-time. This evaluation method can therefore be utilized in any appropriate domain that provides the required information.

Current work in the Evaluator is directed towards the possibility of the inclusion of student performance data in the evaluation process. This would personalize the evaluation in domains where each student needs to be evaluated differently.

Another area of research is the implementation of procedures which will enable the Evaluator to deduce what reasoning strategy is being used by the student in his problem solving approach (cognitive evaluation). This type of cognitive evaluation would go beyond quantitative scoring of responses and arrive at a qualitative assessment of the student's cognitive

style, information processing abilities, types of data being attended to, and hypotheses being generated during the course of solving the problem situations presented in the simulation. Such an assessment would provide a measure of the student's level of expertise in the domain, more in terms of answering the question "Does the student reason like an expert in this field?", or "Does the student approach the problem in a manner similar to how an expert would approach the problem?", in addition to addressing the question of how closely the student's responses match a set of Expert solutions.

WORKSHOP

LEARNER CHARACTERISTICS INVOLVED IN DISTANCE LEARNING

Ann T. Cernicek and Heidi A. Hahn

Distance learning represents a strategy for leveraging resources to solve educational and training needs. Although many distance learning programs have been developed, lessons learned regarding differences between distance learning and traditional education with respect to learner characteristics have not been well documented. Therefore, we conducted a survey of 20 distance learning professionals. The questionnaire was distributed to experts attending the second Distance Learning Conference sponsored by Los Alamos National Laboratory. This survey not only acquired demographic information from each of the respondents but also identified important distance learning student characteristics. Significant distance learner characteristics, which were revealed statistically and which influence the effectiveness of distance learning, include the following: reading level, student autonomy, and self-motivation. Distance learning cannot become a more useful and effective method of instruction without identifying and recognizing learner characteristics. It will be important to consider these characteristics when designing all distance learning courses. This paper will report specific survey findings and their implications for developing distance learning courses.

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Learner Characteristics Involved in Distance Learning

Ann T. Cernicek and Heidi A. Hahn

Introduction Ever since the one room school house, it has been evident that numerous student variables are involved in education. Because the traditional classroom has been around so long, we have been able to identify and accommodate several of these variables. Recently, because of a technological revolution, a new type of education has evolved. It is known as distance education, distance learning, and distributive learning. Putting semantics aside, they all mean the same thing.

Distance learning is **structured learning without the physical presence of an instructor** (Los Alamos National Laboratory Distance Learning Conference, 10/89). Garrison and Shale's definition from the *American Journal of Distance Education* says that distance education implies that **the majority of educational communication between (among) teacher and student(s) occurs noncontiguously** (Sewart, Keegan, and Holmberg, 1988). Distance learning is independent of time and place. It includes print media, video, satellite broadcast, teleconferencing, audio graphics, as well as many other mediums. Student variables, which need to be identified and recognized to make it an effective means of education, are concomitant with this new technology.

The need to explore alternative means of providing education cannot be underestimated as the U.S. is currently undergoing an education crisis. This crisis encompasses many factors, which include declining standardized test performance, the increasing number of functionally illiterate people in the nation, and a perceived apathy toward learning in general. The inefficiencies in the current education system are symptoms of the ongoing education crisis. A single approach will not be sufficient to solve the education crisis; a series of solutions will be necessary.

Thus, the objective of this study was to explore the effectiveness of distance learning as an alternative to traditional classroom instruction. Specifically, the study aimed to identify those student variables needed for distance learning to be successful. What are the learner variables that affect the effectiveness of distance learning? What are the perceptions of experts in the field of distance learning involving learner variables? Student variables must be recognized, identified, and accommodated for distance learning to be successful.

A review of the distance learning literature showed that a great deal of research has been conducted. However, this research is very fragmented; studies differ with respect to scientific rigor and the adequacy of reporting of information and are sometimes inconsistent with respect to the conclusions drawn. Thus, although it is possible to compile a comprehensive list of variables that may impact the effectiveness of distance learning, it is very difficult to assess their relative importance.

Therefore, the goal of this report is to assess the relative importance of learner variables on the effectiveness of distance learning. Experts in distance learning were asked to respond to a survey in which they rated the importance of a large number of variables to the effectiveness of distance learning (versus that of a traditional classroom). Variables included in the survey were selected from the literature and are described below:

- **reading level/education level** - Findings show a positive relationship between education level of the student and completion of a distance learning course (Woodley and Parlett, 1983); reading level may impact the student's ability to process course materials.

- **gender** - Some research claims there are sex differences with males having a higher dropout rate than females (Duby & Giltrow, 1978), but the reasons for this result are not known (Schurman & Blackman, 1989).

- **age** - Findings show that students in their late twenties and older are less likely to drop out of a course than younger students are (Wells, 1990).

- **socioeconomic status** - Low socioeconomic status individuals may have difficulty with independent learning; occupation and educational level may interact with socioeconomic status.

- **geographic location/geographic dispersion** - Distance learning courses have been successful in remote geographic locations with geographic dispersion of the population (Schurman & Blackman, 1989).

- **computer experience** - Students starting computer-based courses have high anxiety about the new media and may drop out if they do not begin with a successful experience (Wong & Wong, 1979).

- **typing skill** - Findings show that successful performance in computer-mediated training is not contingent on the typing ability of the student (Wells, 1990).

- **degree of student autonomy** - Adult learners tend to prefer autonomous learning situations; however, this may not enhance course completion (Harbour, *et al.,* 1990).

- **previous distance learning experience** - Findings show that students who have completed one distance learning course are very likely to complete distance learning courses thereafter (Rekkedal, 1983).

- **self-motivation** - Findings show that intrinsically motivated students internalize course material much more than their extrinsically motivated counterparts (Marton & Svennson, 1982).

Method (Subjects) Twenty experts in the field of distance learning were contacted in this study. They represented four sectors (academia, industry, government, and military) and were attendees at the second Distance Learning Conference sponsored by Los Alamos National Laboratory in Scottsdale, AZ, in June 1990. The experts were identified as those having publications in the field of distance learning and as those having those having ongoing work and influence in the field.

Forty-two percent of the respondents were distance learning administrators and more than half of them had more than five years of experience administering distance learning courses. Nineteen percent of the respondents were course designers and evaluators of distance learning courses. Only four percent had ever been students in a distance learning course.

Their course experience weighed heavily towards industrial training. The heavy training experience was to be expected because it was sample dependent; none of the conference attenders was involved in distance learning at the K-12 level. There was also a great deal of course experience in engineering (17.5%) and science (10%).

A wide variety of delivery systems was used. Computer-based training/ computer-aided instruction (CBT/CAI) was the most widely used (18%), while print was the second most used (17%). One encouraging finding was that all the media that were given as possible response categories were being used, even the new "hi tech" media such as audio graphics, video conferencing, and computer conferencing. The respondents had diverse experience with each of the mediums. The respondents reported that 57% of their courses were delivered by a combination of asynchronous and synchronous methods.

Most of the respondents had experience with relatively short courses. Twenty-six percent of the respondents were involved in courses that were less than a college quarter in length, while twenty-two percent were involved in semester-long courses. The respondents reported that 67% of the distance students they had dealt with were military personnel, 20% were graduate students, and 15% were undergraduate students.

All types of the suggested evaluation methods were being used by the respondents. Interestingly enough, the most frequent method of evaluation was a "hi tech" method (computer, 29%), while the second most used method was a "low tech" method (pencil/paper, 25%). All of the respondents reported they had performed some sort of formal evaluation, most measuring student performance, cost effectiveness, and student attrition rate. Sixty-seven percent of the courses were evaluated against some type of a control group of which ninety-two percent were against the traditional classroom.

Method (Survey Instrument) The survey instrument was a two-part questionnaire. The first part was the demographic data of the respondents. It requested information about the background and experience the respondents had in various aspects of distance learning.

The second part had the respondents rate each student variable on a Likert scale of 1 to 5 (1 being not effective, 5 being very effective). The survey allowed the respondents to make comments throughout the survey. When the respondents made their comments, they were asked to report if it was an opinion or if it was based on experience. Many of the responses and comments were based on actual experience.

Analysis and Results (Analysis Methodology) Because survey data cannot generally be assumed to be normally distributed, non-parametric statistical methods were used in this analysis. The Freidman Rank Sum test was used to determine whether the student variables were perceived to differ with regard to their impact on the effectiveness of distance learning (relative to their impact in traditional settings). The highly significant statistical result ($S' = 48.6$, $p < 0.01$) indicated that the variables were, indeed, viewed as having different impacts on distance learning effectiveness.

Obtaining this significant result allowed us to continue with our analysis, using the Wilcoxon Rank Sum test to assess the relative impact of all possible pairs of variables. Basically, these analyses help to answer the following general question: "Is variable A more or less (or equally) important as variable B in terms of its influence on distance learning effectiveness?" These results are detailed below.

Finally, descriptive statistics were used to explore at what levels within a particular variable identified by the Wilcoxon tests as important distance learning might be most effective.

Analysis and Results (Results) Systemtic patterns of results were found for 5 of the 12 student variables surveyed. These are each described in turn. To help the reader in interpreting these results, means and standard deviations for each variable are shown in Table I.

TABLE !

MEAN AND STANDARD DEVIATION
OF EACH STUDENT VARIABLE

Variable	Mean	Deviation
Gender	2.86	0.86
Reading Level	4.00	1.00
Age	3.67	0.98
Socioeconomic Status	3.53	0.92
Geographic Location	3.62	0.77
Education Level	3.75	1.00
Occupation	3.30	0.95
Computer Experience	3.77	0.72
Typing Skill	3.57	0.75
Student Autonomy	4.50	0.73
Previous DL Experience	3.93	1.14
Self-Motivation	4.73	0.59

- **Gender** - As can be seen from Table II, virtually every variable studied was considered to be more important to distance learning effectiveness than gender. This contradicts evidence from the literature suggesting that gender does impact success in distance learning courses.

TABLE II

WILCOXON TESTS
COMPARING **GENDER**
TO OTHER SURVEY VARIABLES

Gender versus...		
Variable	**w***	**p**
Reading Level	-3.73	**.0001†**
Age	2.74	**.0031†**
Socioeconomic Status	1.85	**.0322†**
Geographic Dispersion	2.11	**.0174†**
Education	2.69	**.0036†**
Occupation	2.61	**.0045†**
Computer Experience	2.75	**.0033†**
Typing Skill	1.92	**.0274†**
Autonomy	4.05	**.0001†**
Previous DL Experience	3.07	**.0011†**
Self-Motivation	3.38	**.0004†**

Legend
† = significant

- **Reading level** - Table III shows that reading level was considered to be less important to distance learning effectiveness than only one variable (namely, self-motivation). Reading level was considered to be more important than most of the demographically-oriented variables, including socioeconomic status, geographic location, computer experience, typing skill, and occupation.

Within the various reading levels, a linear trend was exhibited with respondents' viewing distance learning as more effective as reading level increased; categories rated with their associated means and standard deviations respectively were illiterate (mean = 2.27, SD = 1.44), elementary (mean = 2.67, SD = 1.18), junior high school (mean = 3.07, SD =.83), high school (mean = 3.47, SD =.64), and high school graduate (mean = 4.06, SD = 1.18).

TABLE III

WILCOXON TESTS
COMPARING **READING LEVEL**
TO OTHER SURVEY VARIABLES

Reading Level versus...		
Variable	**w***	**p**
Gender	-3.73	**.0001†**
Age	-1.31	.0951
Socioeconomic Status	-1.67	**.0475†**
Geographic Dispersion	-2.19	**.0143†**
Education	-1.30	.0968
Occupation	-1.81	**.0351†**
Computer Experience	-1.71	**.0436†**
Typing skill	-2.02	**.0217†**
Autonomy	0.990	.1611
Self-Motivation	2.02	**.0217†**
Previous DL Experience	0.19	.4247

<u>Legend</u>
† = significant

- **Previous distance learning experience** - As can be seen from Table IV, previous distance learning experience was viewed as more important to future success in distance learning environments than many of the demographically-oriented variables.

Respondents felt that distance learning was much more effective for students who had experienced a previous distance learning course versus their inexperienced counterparts with means and standard deviations of 4.07/1.2, and 2.73/1.22, respectively.

TABLE IV

WILCOXON TESTS COMPARING
PREVIOUS DISTANCE LEARNING EXPERIENCE
TO OTHER SURVEY VARIABLES

Previous Distance Learning Experience versus...		
Variable	**w***	**p**
Age	-1.14	.1271
Socioeconomic Status	-1.41	**.0793†**
Geographic Dispersion	-1.71	**.0436†**
Occupation	-1.86	**.0314†**
Computer Experience	-1.49	.0681
Typing skill	-1.63	**.0516†**
Autonomy	1.10	.1357
Self-Motivation	2.09	**.0183†**

Legend
† = significant

- **Student autonomy** - Student autonomy was also viewed as very important, compared with other student variables, in ensuring distance learning effectiveness. The result is demonstrated in Table V.

Respondents felt that distance learning was very effective for students with a high level of autonomy (mean =4.5, SD =.73), was moderately effective for partially autonomous students (mean =3.53, SD =.83) and had limited effectiveness for low autonomous students (mean =2.46, SD =1.50).

TABLE V

WILCOXON TESTS
COMPARING **AUTONOMY**
TO OTHER SURVEY VARIABLES

Autonomy versus...		
Variable	**w***	**p**
Age	-4.05	**.0001†**
Socioeconomic Status	-2.51	**.0060†**
Geographic Dispersion	-2.93	**.0017†**
Previous DL Experience	-1.10	.1357
Occupation	-3.11	**.0009†**
Computer Experience	-2.57	**.0051†**
Typing skill	-2.96	**.0015†**
Self-Motivation	1.16	**.1230†**

Legend
† = significant

- **Self-motivation** - Finally, as can be seen from Table VI, self-motivation was viewed as perhaps the most important student variable in terms of contributing to distance learning effectiveness.

Respondents reported that distance learning was much more effective for those students with high self-motivation (mean =4.66, SD =.72) than for students with low self-motivation (mean =2.00, SD =.84).

TABLE VI

WILCOXON TESTS COMPARING
SELF-MOTIVATION
TO OTHER SURVEY VARIABLES

Self-Motivation versus...		
Variable	**w***	**p**
Age	-2.02	**.0217†**
Socioeconomic Status	-3.21	**.0007†**
Geographic Dispersion	-3.66	**.0001†**
Autonomy	-1.16	.1230
Previous DL Experience	-2.09	.0183
Occupation	-3.81	**.0001†**
Computer Experience	-3.65	**.0001†**
Typing Skill	-3.68	**.0001†**

Legend
† = significant

Discussion Clearly, student variables that affect the effectiveness of distance learning are very important. For distance learning to be a viable solution to the education crisis, courses must be well designed and students must be carefully selected. The survey data have highlighted several important student variables that must be considered in the design of distance learning courses.

Reading level, student autonomy, and self-motivation were all identified as having particular importance in distance learning. Specifically, students with a good reading ability and a great deal of autonomy and self-motivation provide a good target population for distance learning. If the instructor could select students that have these characteristics, many of the learner discrepancies in distance learning would be eliminated. Instead, more often than not, distance instructors do not get to choose the type of student who enrolls for the course. Therefore, mechanisms to promote these important characteristics are built into the course design. Thus, these variables should be assessed before a student is assigned to a distance learning course. Students not possessing these qualities may require special support. One such "safety net" might be to allow student-controlled access to an instructor (via e-mail, a computer conference, and/or a telephone hotline) so that help is always available.

Most, if not all, media in distance learning promote a very autonomous learning environment for students. Although there is some interaction with other students and the instructor, the majority of the time distance learning students work independently. Students who need a high degree of structure and explicit instructions often have a hard time in the autonomous learning environments created by distance learning. Reading level proved to be an important skill in distance learning courses because most media are print media. There are several technologies such as audio graphics, CBT/CAI, and audio conferencing that do not focus so heavily on reading. These media should be incorporated in course design if reading deficiencies are expected. Thus, it is essential for the course design to provide some type of safety net for non-autonomous students. By identifying such characteristics at the onset of the course, the student, as well as the instructor, has a much better possibility of succeeding.

Motivation is an essential element in all distance learning courses. Unlike traditional face-to-face classes where students are motivated by the instructor, distance learning students are motivated by the course material and student support services. Baath (1982) distinguishes between students who are intrinsically motivated and extrinsically motivated. Intrinsically motivated students acquire and retain more factual and conceptual knowledge than their extrinsically motivated counterparts. Intrinsically motivated students are more likely to learn concepts and logic while extrinsically motivated students will simply memorize facts. This issue is another one that course designers and instructors need to recognize. Motivational tactics need to be embedded in the course material, which can be done several different ways. Examples include giving short and simple assignments at the beginning of the course to build the students' confidence in the distance learning course and providing interactivity with the student.

Conclusion This study has identified a number of student variables that might fundamentally impact course design in the distance learning environment. Further research is needed. As a first step, a more rigorous statistical analysis will be conducted on the current data to determine both which variables are the most important and for which levels of the variables distance learning is most effective in a statistical sense. Then, a more refined survey will be developed. In the future, it might be advantageous to take this study a step further and gather in-depth data on a limited set of variables to provide very specific recommendations to course designers.

Distance learning can be a viable solution to the education crisis at hand. Distance learning has the ability to cross many boundaries that are otherwise closed to education. We must recognize the potential distance learning has to enhance our education system. At the same time, we must identify the fundamentals of distance education so we can begin to reap the many benefits distance learning has to offer.

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